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THREE quarters of a century devoted for the most part to intellectual culture and the public service, institutes an irresistible claim on the homage of mankind: that sentiment of veneration is intensified when its object has been as distinguished for the elevated character as for the unswerving perseverance of his labours. Sir George Beddell Airy is one of those illustrious examples, and his contributions to science are among the most brilliant as they are the most voluminous in modern times.

"Born in Northumberland four and seventy years ago," writes one, "with a splendid intellect but no inheritance, he has made of himself, by an unremitting course of labour of the most trying kind, what he is,—one of the glories of his country."

Every student of biography is familiar with the ever-recurring examples of distinction claimed by public elementary schools, and all must have felt that, especially in science, these great educational manufactories are of little use. The spirit of emulation which is the basis of a public school is little cultured by a lad of observation, and the splendid advantages of the former are compensated by the opportunity and facility of using all

the means that can be employed in the limited range of provincial grammar schools and private study. The work is not so glittering, but it is equally, if not more, thorough and enduring. The culture is personal; the knowledge exact. Airy took his early training at Hereford and at Colchester, especially the latter, where he remained until, on reaching his eighteenth year; when, having acquired all the honours within his reach, he entered at Trinity College, Cambridge, in the year 1819.

Vigorous in mind as he was in body, he threw himself into the new scene with all the energy that his love of knowledge could inspire, in three years winning a scholarship, and in the following taking his B.A. degree with the position of senior wrangler.

The Cambridge Philosophical Society commenced its existence on Dec. 13 in that year. Airy found himself happily associated with men whose names and services will never be forgotten. They were Brewster, Whewell, Sedgwick, Henslow, Babbage, Herschel and Farish. These found in the young philosopher a friend whose intellectual, scientific, and social temperament, harmonised in aim with their own, and the welcome then bestowed acted on his future life in an extraordinarily stimulating and successful way.

At the age of twenty-one, he read a paper before that Institution, "On the use of Silvered Glass for the Mirrors of Reflecting Telescopes," in which he pointed out the superiority of glass to metal for such purposes, and suggested methods of improvement in their production, which have been adopted and still further improved. By a mere coincidence he ascertained that the idea had been known seventy years before by a Mr. Caleb Smith, who published it in 1740, but it had never been tested by more than one experiment, and had been dormant until its unconscious revival by Airy, who not only gave the idea, but formulated his statements for practical ends in a scientific manner.

The mind of the young philosopher gravitated towards astronomy in its earliest stages. Theories that found favour with him were those which bore upon that subject, and every week brought him convincing evidence of the loose and unsatisfactory condition of all the statements concerning that branch of natural study. In 1824, he read a paper, "On the Figure assumed by a Fluid Homogeneous Mass, whose particles are acted on by their Mutual Attraction and by small Extraneous Forces," in which he combated the theories of La Place concerning the Ring of Saturn, bringing out a conclusion by mathematical calculations differing from that of Sir John Herschel, which was then the accepted one, and exhibiting, as he states, "a complete discordance between theory and observation, and showing the necessity for further knowledge of that planet before any reconciliation between these could be rationally maintained."

This revealed Airy's mathematical power, and he at once took up a position as a devotee of that science, applying it in every direction that bore upon his favourite study and on other subjects. Three months afterwards he appeared before the society with a paper, "On the Principles and Construction of the Achromatic Eye-Pieces of Telescopes, and on the Achromatism of Microscopes," a subject very interesting in the theory of telescopes, and containing much important knowledge as to their construction; these he treated in a purely mathematical manner. Further experiments showed him that, while he could demonstrate the imperfection of optical instruments, there remained another element more disturbing, to which he applied his investigations, and produced another contribution, "On a Particular Defect in the Eye, and a Mode of Correcting it." He had observed, as is the case with many others, that his own eyes were not of equal service, and set himself to ascertain the cause, and so to define the phenomena as to bring about a remedy.

These services led to his nomination for the office of Lucasian Professor of Cambridge in 1826. His opponents were his subsequent friend and then a familiar acquaintance, Mr. Charles Babbage, and some others; but the opposition lost, and Airy took the office. Of late the professorship had been unrighteously dealt with,—it had a become a sinecure. The authorities of the University gave little or no encouragement to the disciples of natural philosophy, and were indeed somewhat jealous of the subject. Airy resolved that at any rate he would earn his money and emulate his great predecessors by a constant endeavour to acquire and impart knowledge that would be worthy of the University, and advance the cause of natural philosophy by elevating it in public esteem.

The Mathematical Professorship dates from 1663, and was the last public work of Mr. Lucas, the M.P. for Cambridge University. Barrow held it for six years, and was succeeded by Isaac Newton, whose tenure of office extended over thirty years. The eccentric and learned Whiston followed, but he was excommunicated on the ground of theological heresy. From that time the office ceased to be of any service to the intellectual development of England; the authorities found that proving was all very well, but proving might produce inconvenience. Mr. Newton had done something to distrust dogma, and Mr. Whiston had not only followed suit, but added satire most caustic. Under these circumstances the office became a mere sinecure: the founder had left the money, and that must of course be kept; but the purpose of the donor was not fulfilled because of general and clerical expediency.

Just at this time a school had been formed at Cambridge of men who loved demonstration. Their names are cited already. Brewster and his optics; Whewell and his education projects, his mathematics, his moral philosophy, and philosophy of the inductive sciences, and all the others in their several ways, were bent on knowing all that could be positive, and rejecting what was proved to be absurd. The rising tide carried Airy into the neglected chair, for which he had further shown his worthiness by the publication of "Mathematical Tracts for the benefit of Students," in which he was aided by the funds of the university at the disposal of the Syndics. These are on Physical Astronomy, the Figure of the Earth, Precession and Nutation, and the Calculus of Variations. The first is properly on the Lunar Theory, and was the first book on the subject. The second aims to perfect the teaching of Machanoun and Clairant by simplifying their theorems and speculations. The third had no predecessor; Newton's propositions had been proved imperfect and erroneous, and needed revision. The last is a most valuable aid; it inculcates the duty of accuracy by rigorous adherence to principles, by testing every formula and working it through, and enforces the throwing aside all useless theorems.

His first professorial work was to deliver a series of lectures "On the Undulating Theory of Light;" and his reputation grew rapidly. He became Professor of Experimental Philosophy and Astronomy, a chair founded in 1704 by Thomas Plume, Archdeacon of Rochester, and to this the university added a Fellowship in Trinity College.

These distinctions acted as a stimulus to their possessor, and the enlargement of his range of subjects mathematically treated. In 1826 there came from him a paper on "The Disturbances of Pendulums and Balances, and on the Theory of Escapements," in which for the first time is propounded a distinct theory of great importance to the horologist, because of its simplicity, and because its principle is comprehensive.

His astronomical honour as Plumian Professor of Astronomy placed him in the office of Principal in the new Cambridge Observatory, whither he removed; here he pursued another class of investigations, without relaxing in the fulfilment of the engagements already made. Of these we shall have occasion to speak separately. The Philosophical Society received from his pen contributions besides those named, "On the Spherical Aberration of the Eye-pieces of Telescopes," a continuation of former investigations, of the conditions most favourable for the destructions of spherical aberration, the importance of which have "been acknowledged by every scientific artist, and every writer who has endeavoured to assist by practical rules the common workman." An intricate and difficult task is executed in a manner and style that imparts interest to what otherwise and in other hands is the driest of technicalities, and the scientific find in the mathematical calculations an aspect affording more pleasure than even that science commonly affords. Then, "On Certain Conditions under which a Perpetual Motion is Possible," a fragment that ought not to be unfruitful in practical applications, although chiefly suggestive. Force expends itself, and cannot be perpetuated. But out of the endeavour to discover the laws he indicates much that is of utility. In 1831, another, "On the Nature of Light in the Two Rays produced by the Double Refraction of Quartz," and this also may be, although of considerable length, termed suggestive rather than positive. Quartz is not fully known, and the paper refers to the points necessary to be studied and experimented upon. This good, however, came of his labour. He directed Mr. Dollond to construct an apparatus, which, for convenience and extent of application, exceeded all others. This is described in Vol. IV. of the Society's Transactions, page 204, and illustrated by coloured plates.

On the 14th November, "On a Remarkable Modification of Newton's Rings," followed by another on the same subject six months afterwards. He advocated the undulated theory of light, and in a manner that reminds one of the late M. Faraday. The clearness of his own perceptions and the modesty of expression attract attention and excite thought. The same remark applies to his other papers, such as that on "The Latitude of Cambridge Observatory," and that on "The Intensity of Light in the neighbourhood of a Caustic," which was read twice, once in 1836, and again in 1838.

Happening, in 1837, to be on a visit to Neath in Glamorganshire, he received a request to deliver an address to the members of the Philosophical Society in that town. Secluded from

contact with large towns, and the site of many historic associations, this ancient port gives to its district a unity peculiar among provincial boroughs. Copper and iron works, collieries, foundries, and manufactories, make it a good place for business, and the oocupations of the people tend to produce a thirst after knowledge. Airy's address had two divisions—1, How provincial societies can contribute to the science of the world generally; and, 2, How they can aid the instruction of their members and the inhabitants of their districts. Defining science as the collecting and arranging of observed facts, he showed its function is to ascertain what appearances always accompany other appearances, or what modifications of matter or of form may be certainly expected to follow changes. Limiting science to facts because it has nothing to do with causes, he illustrated from the iron-worker, who knows that air will produce oxide, and in another case by a blast reduce heated oxide to a metallic state, and is only required to say that such is the fact, he showed that "the reason why" was neither in his power nor was it his business to explain. The same method rules with the chemist and the geologist. The extent of facts collected in the memory, their distinct arrangement, the sagacity in conjecturing by inferences therefrom, and the care in ascertaining the truth or falsehood of premisses, vary; but in all, the nature of science is the same, and its limitations are fixed.

He proceeded to insist that the advancement of natural science is common to all; the provincial, or the philosopher, were on a level. Many not devoted to science possessed this acquisitive and arranging faculty in a greater degree than students, and the difference between the practical man and the philosopher consisted in the largeness of grasp, but not in the power of accurate and positive scientific faculty. The practical man could further aid science by contributing numerical measures of quantity, distance, elevation, and the like, common to such works as mining and manufactures. In general, the important steps of science have not been made so much by professors as persons not officially connected therewith, but who have followed a natural inclination, according to the facilities offered in their daily employment, mentioning Herschel who, a military musician, had a liking for telescope-grinding that led him to establish a new department of astronomy; and William Smith, a land surveyor and land agent, by being interested in strata, was able to discover in part the law of the order of succession of strata as identified by organic remains, and so led Lyell and Murchison in the march towards perfecting Geological Science.

He then urged the importance of local museums, particularly in geological districts. Individuals can do but little alone: they cannot benefit the world in any appreciable degree, but combined, an active local institution can soon place permanent records, in the forms of specimens, that shall be of perpetual use to students of the science, and of great advantage in the development of the natural riches of a district. The same remarks are applied to the importance of a kind of local survey of the rate of fall in rivers, and the elevations of hills, as useful when new roads, canals, adits, &c., are proposed for the development of natural resources, and for commerce: works which only take a little occasional leisure, but in the aggregate are invaluable to a stranger, who then beholds the riches of the locality in miniature; and useful to the residents in prestige and in fruit. So of facts concerning tide gauges, meteorology, astronomy, magnetism, which should be collected by means of the best instruments, and made available for ever by the publication of Transactions.

Then as to making such labour bear on the science of the world he recommends localities to have schools of practical geology, collections of philosophical apparatus, and schools of chemistry, containing all that can be obtained, and adding thereto for the general good, instancing Watt, who from seeing a model at an institution in Glasgow, was led to his great steam engine projects. He then dilated on his favourite subject, astronomy, and finally commended the practice of lectures, showing how that mode of instruction could be improved by local aids, such as he had recommended.

The foundation of the new observatory at Cambridge, gave scope for Airy's highest impulses and the development of his confined unrealized thoughts, because it afforded an opportunity for the creation and setting up of a new class of instruments for observation, which was then so greatly needed. Learned men had begun to question the Greenwich result, and even to confute them, and yet there remained no other machinery where more perfect tests could be applied or higher facts acquired. Certainly the enterprise at Cambridge received magnificent support. The expense of construction and instruments stood not in the way, being unrestricted, and the noble and distinguished savans of the Philosophical Society there were not the men to do things by halves. A new building arose, having its own meridian and evolving its own details independently. These Airy collected with the other chronicles of the old observatory and issued them in handsome quarto volumes, arranging all the matter from 1828 to 1835 and from 1740 to 1828, in a clear and simple form, but with the most perfect accuracy. His scheme for calculation and publication were at once recognised as the most complete, and far more serviceable than those previously adopted in any observatory. They were promptly adopted at Greenwich, at Paris, and at the best continental observatories. But it was in the new instruments he made his best mark. He personally superintended the mounting of the Equatorial, the Mural Circle, and the Northumberland telescope, which last is really his own invention, and is a visible exposition of the union of mechanical and optical scientific power that distinguishes the man. He showed by many examples the endowments he possessed in this direction, but that evidence appeals to the popular mind more readily than the more delicate and abstractly scientific aids he had projected and superintended to completion.

Again did honours come upon him. This time, after having received the appointment of Astronomer Royal, through Lord Auckland, First Lord, and become President of the Astronomical Society, and one of the permanent Council in the same year, he obtained the position of President-Elect of the Royal Society. This brought him into more frequent contact with London Society of the intellectual order, and led to his acceptance of office in the new University of London, just then preparing to launch. Airy became one of the First Senate.

Greenwich, like Cambridge, soon felt the influence of a powerful and energetic mind. The wisdom of the man is apparent in the prudence with which he treated the ancient ways, stupid and inefficient as some of them were. Gently did he introduce his new methods for superseding the old; waiting until their superiority was clearly evidenced before attempting to destroy or remove traditionary methods; and hence, while metamorphosing the whole place, and disturbing and transforming all that was therein, he encountered no opposition, and made no enemies.

Airy's popularity as a Lecturer on Experimental Philosophy led to his name coming before the Committee of the Society for the Diffusion of Useful Knowledge, who were projecting, under Mr. Long, the Penny Cyclopædia, a book published by Mr. Charles Knight, and in several respects unequalled to this day. He received a request to prepare an article on Gravitation. The idea acted influentially upon him. He saw it deserved instant attention, and went to work. Seven years must have elapsed before his article could appear in the Cyclopædia, and he arranged for its separate publication, preparatory to its issue in the Cyclopædia. Accordingly, "Gravitation, or the Perturbations of the Solar System," was issued as a help to students. Again the learned public recognised the hand of a master qualified, not only to guide students, but to unveil mysteries that had defied the keenest acumen. The book is a recognised witness to Airy's mental power. His design contemplated the avoidance of mathematics in order that he might augment the general interest in the subject, and make it increasingly useful. He found himself driven to adopt geometrical explanations, which, although in most cases more readily apprehended and easier, are not very much simpler: but if a perfect demonstration is absent, the principle of form and intuitive knowledge lead to a sound conclusion. It is an admirable contribution to Physical Astronomy, and a most advantageous advance on Newton's celebrated eleventh lecture.

When Airy was writing his many aids to students in books and in lectures, he frequently received suggestions from friends, and among these was Dr. Peacock; but the busy life had not sufficient leisure or time to undertake them all. The suggestion referred to was on "Sound and Atmospheric Vibration with the Mathematical Elements of Music: designed for the use of students in the University." It took more than thirty years to find time and a proper opportunity for that purpose; but when that event came, all felt that no time had been wasted. It discusses mathematically on "The General Recognition of Air as the Medium which conveys Sound; the Properties of Air; the Theory of Undulations of Sound and the Investigation of a Passage of a Wave of Air through a Cylindrical Pipe or of a Plane Wave through the Atmosphere generally; Investigation on the Motion of a Wave of Air of varying dimensions; the Transmission of Waves of Soniferous Vibrations through Gases, Solids, and Fluids; Experiments on the Velocity of Sound and on the Pressure accompanying Atmospheric Waves; on Musical Sounds, and the Manner of producing them; on the Elements of Musical Harmony and Melody, and of Simple Musical Composition; on Instrumental Music and the Adaptations of Music required by special Instruments; and on the Human Organ of Speech and Hearing." These are treated with scientific accuracy, and combine to make the book one of the best authorities in a very difficult line of knowledge.

None can be surprised that a lover of astronomy should be also a Biblical student. It is well-nigh impossible for the human mind, when trained to a knowledge of the starry world and the order of the Universe, to avoid a faith in the personality of the Deity and in his control of the vast complicated results of creation. The speculations about the Old Book by Donaldson, Essays and Reviews, and Bishop Colenso, induced Airy to make known a collection of private notes on the ancient Hebrew Scriptures. In them he discards verbal inspiration, and invites on reverential grounds the freest criticism; at the same time the question of personal inspiration is left open, because it is not unreasonable that the Great Mind should on occasion control the thoughts of his faithful servants. But quotations of the Old in the New Testament are deemed of no critical value, or of any kind of authority; and any divergence from the known laws of nature in the statements of the Hebrew Scriptures may be set aside without invalidating the usefulness of the Bible. The volume is one we need not discuss in these columns, but it marks the existence of a pure, candid, and generous nature of marvellous acumen and of dignified humility. Airy had many years before manifested his affection for the absolute unity of religious and general culture, holding them to be inseparable if the human mind were to be hopefully trained. Hence he opposed the abolition of examination in religious works in 1838 in the London University Council, as wrong in principle and a violation of public faith. Subsequently there occurred many instances of his solicitude in every effort to blend the religious instruction and general study in one free but united welding; notably in his letter to the *Times* on that subject in connection with parental obligations and sound domestic training.

Sir John Herschel undertook in 1826 to communicate to the Royal Society a paper from Mr. Airy "On the Figure of the Earth." It is a mathematical paper elucidating his theory that the earth's figure is not an elliptic spheroid, and supplies formulæ for determining exactly the figure when other calculations are completed. The whole is abstract science and of much interest to those who have a preference for such study. In 1827 the Board of Longitude finding a variation between the computed and observed right ascensions of the Sun since the erection of the new transit instrument, requested a report from the Astronomer Royal, and Mr Airy was requested to ascertain the causes of error, so that the Nautical Almanac might be correct. This he did, and subsequently edited that publication. The work involved immense calculations exhausting health and spirits: the discrepancies were subtle and exceedingly difficult to trace. On Nov 24, 1831, Sir J. Lubbock in the chair, Mr. Airy read a paper entitled, "On an Inequality of Long Period in the Motions of the Earth and Venus," giving an account of the method of calculation, and defining the terms used. The labour of preparing these two papers can never be adequately described. The figures and signs are innumerable. In 1832 these were discussed, and Whewell appended a note, "We regard this paper as the first specific improvement in the solar tables made by an Englishman since the time of Halley, as valuable from the care employed as for the sagacity displayed in the detection of an inequality so small and of so large period."

We have had occasion in previous numbers to notice the difficulties marine engineers have had to encounter in reference to the disturbance of the compass in iron-built ships. Airy made, at the request of the Board of Admiralty, a series of experiments, and published the result in the year 1840. There has been a great accumulation of knowledge on the subject since that time, but the foundation may be fairly ascribed to the work of this eminent man. He wrote a series of practical rules, which were published by authority in the U. S. Journal, June 1840, entitled, "Directions for Correcting the Compass in Iron-built Ships." These are nineteen in number, and are so easy that any intelligent person accustomed to use a compass might go through all with certainty.

In connection with Mr. Christie, Airy addressed a Report to the Duke of Sussex, the President of the Royal Society in 1836, on a Letter addressed by Baron Humboldt, developing a plan for observing the Phenomena of Terrestrial Magnetism, and forming a theory based upon his wonderful investigations in the equinoctial regions of America. This, like fifty other subjects, would make an article of itself, and must be left. It led to the establishment of magnetical observations, the fruit of which we are really beginning to gather. In 1841 he read a note "On the Rise and Fall of the Tides in the Thames," and another on the meteorological instruments at the Greenwich Observatory, followed by another in 1843, "On the Laws of Individual Tides at Southampton and Ipswich," contending that the peculiarities did not depend on atmospheric variations, but probably were connected with the laws regulating waves in canals. We find him in 1844 communicating another, "On the Laws of the Tides on the Coast of Ireland, from Observations made through the Ordnance Survey." This paper brought him in 1845 the royal medal of the Society, at which the President said, "It is a great gratification to me to give a medal conferred by his Sovereign to one to whom is committed the charge of the great scientific establishment of England, for investigations connected with the mighty element on which this country has reaped so much glory, and to which she owes so much of her wealth and safety," &c.

The *Proceedings* chronicle another in 1837, entitled "On the Relation of the Direction of the Wind to the Age of the Moon." It arose from a desire to test a general Norwegian belief in the prevalence of northerly winds about the time of the new moon, and it negatives the asserted law by data and other evidence. In 1853 he read a paper "On the Eclipses of Agatheocles, Thales, and Xerxes," very learned, and of great astronomical interest.

Then in 1855 he sent in a paper—"Account of Pendulum Experiments in the Harton Colliery for the purpose of determining the Mean Density of the Earth," to which he added a supplement in 1856. A valuable contribution to general knowledge was his "Account of the Construction of the New National Standard of Length, and of its principal Copies," in 1857. The documents, and some of the disposable copies of measures, are still at the Greenwich Observatory for the public inspection and service.

Returning to an old subject, Airy gave in 1862 an article "On the Difference in the Properties of Hot Rolled and Cold Rolled Malleable Iron as regards the Power of receiving and retaining Induced Magnetism of Subpermanent Characters," and in the following year one "On the Diurnal Inequalities of Terrestrial Magnetism as deduced from Observations at Greenwich"—an epitomized result of a long series of voluminous calculations and observations of the utmost value to those who have charge of or are connected with observations, private or public. Also, again, reverting to a former study—"First Analysis of 177 Magnetic Storms registered at Greenwich between 1841 to 1857, accompanied by suggestions of a practical kind for the use of those who make observations at widely separated parts of the earth." In 1867 he added to that "Comparison of Magnetic Disturbances recorded by the Self-Registering Magnetometers at the Royal Observatory," a most interesting report of the result of experimental wires between Greenwich, Croydon, and Dartford, in reference to Magnetic Disturbances, which most ingenious mechanism is still in constant and successful operation.

These were succeeded in 1868 by a paper "On the Diurnal and Annual Inequalities of Terrestrial Magnetism as deduced from Observations," &c., being a continuation of the former dates, with a note on the lunar phenomena of the same type.

It became evident that Airy must formulate his ideas for the general culture, and he was induced to issue in 1870 his celebrated "Treatise on Magnetism, designed for the use of Students in the University." This is essentially a work for university teaching, in which the subject is treated mathematically, and by mathematics of the highest order. His literary career is seen to be guided by a determination to promote and exalt the study of mathematical physics, and in this volume he first treats of the diffusion of the magnetic element through the universe, asserting that sun, moon, and earth are really magnets. He doubts whether terrestrial magnetism is produced by external magnetism, or that it is in the earth's crust, and names three theories that may include all the phenomena. First, the action of a small powerful magnet near the centre of the earth; second, the action of two magnets within the earth; and, thirdly, a probability that different kinds of magnetism are irregularly distributed throughout the earth; and this last is spoken of as "one of the most elaborate mathematical calculations, and one of the most beautiful and important of modern investigations in physical mathematics."

On publishing a second edition of the *Mathematical Tracts*, Airy added a chapter on the Undulating Theory of Optics, for which he claimed equal attention to his Theory of Gravitation; namely, that it was true, and that by mathematical operations of great elegance, it led to results of great interest. Thirty-five years after he republished that essay, and expanded it into a book, "designed for the use of students." He had tested his theory in every way since first evolving it, and believing that there was no physical theory so firmly established as that, having repeated nearly every experiment then alluded to, he put it forth in book form. He admits only those phenomena which admit of calculations, and which have been observed, excluding all that in any way depend on the imagination.

The Society of Antiquarians found in him a useful colleague, and after a spirited controversy had arisen in the Athenæum about a paper he read before the Society on the Invasion of Britain by Julius Cæsar in 860, the whole was privately printed in a large 4to pamphlet with plates. The writer disapproved of

all previous conclusions as to the locality of Cæsar's departure, his navigation, the place of his arrival, and his subsequent march. It is a scholarly production of much interest to historical students, but not of much service to practical readers, save as it reveals the rich treasures of an intellect, and the profitable uses to which a student can put the knowledge obtained in one department into the service of another, and while investigating one class of facts can find time to gather up many others, and maintain their sequence to advantage.

The Corporation of London presented the freedom of the City to Sir G. B. Airy on the 4th November, 1875, when the City Chamberlain said in his address: "Yours is the first name associated with the sciences other than those of war and statecraft. . . . . The triumphs of science are among the greatest of victories. Astronomy has in the nineteenth century made perhaps greater progress than any of the kindred sciences. Not only have the planetary bodies, known to exist, increased in number more than twenty-fold, but beyond the area of our system astonishing discoveries have been made, extending almost without limit our acquaintance with the physical universe, while, stranger than fiction, the heavenly bodies have had to yield up the secrets of their composition, and that of the gases which make their atmospheres. This has made astronomy one of the most attractive of studies. . . . . Leaving to others fields of explorations, you, Sir George, have incessantly devoted yourself to the more valuable walks of practical astronomy; and it is this which has attracted the attention of the Corporation, who in their resolution recognises, especially 'your eminent services in the advancement of practical science, whereby you have so materially benefited the cause of commerce and civilisation.' By nautical tables, by improving chronometers placed for your observation and correction, our naval and merchant services have been enabled to navigate in safety in protecting the commerce of the seas. When insurmountable difficulties obstructed the navigation by iron vessels, your solution of magnetic problems swept away all difficulties. When the national standards of measures and ponderosity were lost to the nation, you were appealed to for their restoration, and recently you undertook the very onerous and responsible task of organising and superintending the expeditions sent over the globe to observe the transit of Venus. . . . Allow me to express the hope that in unbroken health and uncloudedintellect you may be permitted to watch over the completion of this noblest problem of practical astronomy with which your name will ever be associated until the end of time."

In his reply Sir George Airy expressed his sense of the value of such a testimonial from the city as "different from anything I have ever received in my life, and there are many things which make me value this honour extremely." He then alluded, in most pathetic terms, to the name of a friend of his youth, Thomas Clarkson, the associate of Wilberforce in the slave liberation, who had preceded him in the reception of city honours by many years. And in continuation, "When I was a young man," said he, "a student at Cambridge, and rather poor than not, I received a small exhibition from one of the city companies. It came through hands I did not know, and was the first money I ever possessed of my own. It gave me independence. How much it may have contributed to what some call success I cannot say, but that it did contribute I have no doubt." This transaction stands upon the city annals with especial honour, and the journals of the Corporation contain all the particulars at length.

There is a little contribution of Sir G. B. Airy's in the British Museum, which was privately presented in 1873, "On the Topography of the Lady of the Lake." It is really notes of his visit to the Trossachs with Sir Walter Scott's book in hand, and exhibits the author in the enviable light of a most amiable friend, who "thought it might be interesting to some tourists that I should prepare a Topographical Commentary on the poem; and it appeared probable that I might really add to their enjoyment both of the poem and of the scenery, by placing before them in close connection the descriptive features of both," and corroborates Sir Walter's testimony in the Introduction to the *Lady of the Lake*—"I took uncommon pains to verify the accuracy of the local circumstances of this story." This is also out of our scope, but it manifests the mind we are trying to describe.

The proceedings of the Royal Society contain dozens of the Astronomer Royal's contributions, as has been noticed. These are on various subjects, and commencing June 15, 1826. Dec. 11, 1862, is mechanical. "I have long desired," said he, "to possess a theory which should enable me to express and to compute numerically the actual strain or strains upon every point in the interior of a beam or girder, under circumstances analogous to those which occur in ordinary engineering applications—partly for information on the amount of force actually sustained by the different particles of the cast or wrought iron in a solid beam, partly as a guide in the construction of latticed bridges. . . . . I have therefore constructed a theory in a form which I believe is new, which solves completely the problems I had proposed to myself, and which, as I think, may, with due attention to details, be applied to all the cases that are likely to present themselves as interesting." The whole treatise is mathematical, and illustrated by drawings.

His papers on Magnetism are as valuable as those on Astronomy. We name three:—Dec. 1869, "On an Extension of the Comparison of Magnetic Disturbances with Magnetic Effects, inferred from Terrestrial Galvanic Currents; and Discussion of the Magnetic Effects inferred on days of Tranquil Magnetism." He contends that there is a real law of diurnal changes of galvanic currents; a constant turn towards the north, and a still larger force towards the west, and as no light is obtained on the origin of these accidents, they probably depend on the nature of earth-connections. These are suggestive.

Dec. 1871—"Experiments on the Directive Power of large Steel Magnets, of Bars of Magnetised Soft Iron, and of Galvanic Coils, in their action on External Small Magnets." This describes the result obtained through special apparatus he had prepared, and his specific points are—1. At a constant distance from the steel, the greatest force exerted by a magnet is not the longitudinal force *at* the end, but the transversal force *near* the end. 2. The law of attraction of the core of a galvanic coil is not very different from that of a magnet. 3. The force produced by the core within the coil. In some positions it is 40 times as great, and in some 170 times. 4. The law of force at different parts of the coil differs greatly from that at corresponding parts of the magnet or core. In the coil it is far greater at the end, and the direction different. Near the end of the magnet or core the directions of force converge to a point within it, and about $\frac{1}{12}$ its length from the end. Near the end of the coil the directions of the force converge to a point as exactly as possible at the centre of the end of the coil. These items are demonstrated by drawings and tables of figures. Their importance must be obvious to every man of science.

Dec. 1872—"Magnetical Observations in the Britannia and Conway Tubular Bridges," from experiments necessary from the existence of perpetual tremor to which the iron of those structures is subjected, and to know the cause. He describes the manner of his proceedings, and the result.

Sir George Airy resigned his office of President to the Royal Society in 1873, because of "the severity of official duties which seem to increase, while vigour to discharge them does not increase, and the distance of his residence." He referred to the gradual migration of the Society westward, beginning at Crane Court, then to Somerset House, and finally to Piccadilly, where, having opened the first meeting, he left the chair. But his services while there must be recited, for their importance is great, and the impetus given to general science thereby most conspicuous.

The Vice Chancellor of the University of Cambridge requested the Astronomer Royal to deliver the lecture on Sir Robert Reid's foundation, and accordingly he did so, pointing out the advantages that might be expected to follow the establishment of the lecture, and referring to the defects in the University System of Education as connected with Mathematical Physics. This brought him into direct communication with the authorities, who were anxious to perfect their ordinary curriculum at all times, and Airy showed that, while treatises on the general topics of Natural Philosophy were abundant, it was desirable to provide for the subject of Tides, Waves, Sound, Electricity and Magnetism as well as for some of the modifications of Pure Mathematics, specially applicable to the Observing Sciences. He engaged to supply a part of this want, and hence his well-known Treatise on Magnetism, assisted in the diagram portion by Messrs. Glaisher & Carpenter, his assistants at Greenwich. It is a mathematical work throughout, and its last paragraph is worth repeating, "*On the whole, we must express our opinion, that the general cause of the Earth's magnetism still remains one of the mysteries of cosmical physics;*" a conclusion at once candid and stimulative to new efforts of research.

Professor Airy undertook the charge of an expedition to Spain in 1860, to observe the total eclipse of the sun and to make sundry prescribed and unprescribed observations that would be of service on future occasions. "The morning began in clouds, but brightened into fineness, and the contact took place at 1.48.1." On the progress of the eclipse, he writes, "I have nothing to remark except that I thought the singular darkening of the landscape, peculiar to an eclipse, to be sadder than usual; caused, I conceive, by the diminution of light on the higher strata of air. When the sun is heavily clouded, still the upper atmosphere is brilliantly illuminated, and the diffused light which comes from it is agreeable to the

eye. But when the sun is partially eclipsed the illumination of the atmosphere for many miles round is also diminished, and the eye is oppressed by the absence of the light which usually comes from it. I had a wax candle lighted in a lantern, correcting the appreciations of my eye by reference to this. I found that the darkness of the approaching totality was much less striking than in the eclipses of 1842 and 1851. In my anxiety to lose nothing at the telescope, I did not see the approach of the dark shadow through the air ; but from what I saw of its retreat it must have been very awful.

"At 2.59.30, I commenced counting the beats of my watch by holding it to my ear, recommencing with every 25 beats. When, from the narrowness of the sun's line, I judged that the totality would occur in 10 or 15 seconds, I withdrew the graduated coloured glass. To my infinite astonishment, while the white sun was still shining brilliantly, I saw in great splendour two red prominences and one double floating red cloud. . . . . Before the white disc had disappeared, the white corona formed round the moon all at once, and the moon was seen complete, with dazzling sun, brilliant corona, and brilliant prominences.

"The quality of the colour was full blush-red, or nearly lake, diluted with white, and more diluted at the root of the prominences, close to the moon's limb. About the middle of the totality I ceased from my measures to view the prospect with the naked eye. I could have read a chronometer face at the distance of 12 inches ; nevertheless, it was not easy to walk where the ground happened to be uneven in the least. The outlines of the mountains were clear, but all distances were totally lost ; they were an undivided mass of black to within a small distance of the spectator. Above these, to 6 or 8 deg. in height, was a brilliant yellow and orange sky, without any trace of the blush seen in 1851. Higher still the sky was moderately dark. The corona gave a considerable body of light, resembling the ornament round a compass card. The thing which most struck me was the great brilliancy of Jupiter and Procyon, so near to the sun. They could not have been seen at all except for the total abstinence of illumination on that part of the atmosphere through which their light passed.

"On resuming my measures, I was surprised by the appearance of the scarlet sierra, announcing the approach of the sun's limb. . . . . The sun at length appeared, extinguishing the sierra, and I quitted the telescope and looked around me in S.E. direction for 10 seconds ; as the light grew stronger the darkness in the S.W. attracted my attention, and before long it looked as if the very air was composed of blackness and opacity. The mountains were lost."

We have culled this to indicate the quality of the astronomer's observations and his method of description ; it is also a good lesson for the general public in teaching them "how to see." He adds much scientific information in his paper, and closes by saying :—

"It is scarcely possible that I should observe a fourth total eclipse, and I can therefore only offer to future observers the advice upon which I should have acted myself. Whatever be the trouble and expense, and however small the chance of success in the observation, *use a good steady equatorial, driven by good clock-work, and having easy transversal adjustments for the wire frame.*"

There have been great astronomers whose lives have been immortalised by their discoveries, but there has never risen a Sir G. B. Airy. His special gift is to clear up, perfect, or correct all that have preceded him. This is done on strict mathematical forms ; and, among the jealousies of professional life it can be said of him that while his greatness is unimpeachable, he has no detractor. The deprecating sneerer or the captious detractive pass him by as one both too great and too good for assault. His communications are counted by hundreds, and include a great multitude of original theories or revived ones that had been forgotten ; and yet the polemic in science never ventures to attack, much less to destroy. His appointment to Greenwich, and all the honours which adorn his name, have come from the inevitable ; and none venture to question the appropriateness which has led to his pre-eminence, nor behold his position without feeling that the sources from whence those honours have flowed have been as much distinguished in their bestowal as the recipient in their acceptance.

But it is a remarkable proof of the estimation in which men of the highest worth are held in England, that at the age of seventy-four Sir George was made a Companion of the Bath, and at two and seventy a Commander. "Perhaps," says a satirist, "when he has performed a greater service to the country than the Prince . . . or the Lord . . . he may be admitted to the Grand Cross. But then he will be no greater than he is."

W. S. C.

THE INDUSTRIES AND PRODUCTS OF JAPAN.

MUCH of the great reputation attached to the English name among the nations of the world has been acquired and is maintained from the fact of English sympathies being always ready to welcome every step of civilisation, and by reciprocity willing to assist in developing the riches and genius of every tribe of man under heaven. This trait in our national character gives us power without its being sought for, and influence without effort. It is the basis of our commerce, and is the chief cause of our preponderating weight in all matters involving the growth of freedom and the diffusion of the principles of popular self-reliance. We propose to set forth from official sources a class of facts about the industries and products of Japan, in order, not only to impart knowledge, but if possible to augment our interest in that far-off region and in that singularly constituted race.

The Lacquer Ware of Japan is one of the most characteristic of its productions. The material, the design, and the market, are almost solely Japanese, and a very considerable surplus is sent from thence as exports. It stands about fifth in relative importance on the export list, and amounts to about 200,000 dollars annually.

The lacquer ware for export is, as a rule, that description into which a preparation of gold powder enters, and known to Japanese as *makiyé;* but as many articles of daily household use in Japan are of plain lacquered ware—that is, without ornament—the material is of wood, with a coating of plain lacquer or varnish, the industry, whether for export or for home purposes, is especially interesting, and the production affords employment to a very large proportion of the people.

The groundwork of lacquer consists in the sap of the "urushi" trees, the fruit of which produces the vegetable wax. This tree is distinguished by the Japanese as male and female —the former bearing no fruit. It grows to a height of 36 to 42 feet. Where the trade in this varnish is of any importance, the varnish is taken from the tree when it has become 6 or 7 years old, and after that the tree is cut down. Where the tree is cultivated for the wax, the sap is not extracted. There are two methods of cultivation ; either sowing, or by cuttings. In the former the fruit is lightly pounded in a mortar so as to remove the rind from the seed. These are then mixed with wood ashes, moistened with water, afterwards put into straw-bags, over which liquid manure is poured, and the bags are then left to soak in water until the close of winter. In early spring the seed is sown broad-cast, and lightly covered with earth. Cuttings are planted in rows, and thinned out when the leaf appears ; but sowing is much preferred.

After five years the tree is about 6 inches in diameter, and is nearly ripe. The manner of drawing off the sap is as follows : —A lateral incision is made with a knife in the trunk of the tree, and four days later the incision is punctured. The exuding sap is carefully removed with a small spatula, and put into a wooden jar. One incision is made at a time, commencing from the root upwards, and the trees are taken in turn. This is continued until each tree exhibits a series of cuts all up the trunk, and then the tree is felled. The drawing is begun in the middle of the summer, and continues to the end of November : the quality of that drawn last is the finest.

Another source of supply is the wild tree, but it is poor ; and another that grows like ivy on other trees, but it yields little sap. The labourer who draws sap earns good wages, and is a skilful hand. The produce enriches the owner, for he can obtain 100 dollars for every 133 lbs. of lacquer varnish, and the wood is much sought after for many superior uses.

The art of lacquering does not claim a high antiquity, having, it is supposed, been discovered about the year 900, and then another four centuries elapsed before any conspicuous success ensued through the labours of one enthusiast, who applied his skill as an artist to the ornamentation of lacquered goods. The following is a general description of the mode in which designs in lacquer are worked :—

The first thing is to trace out on the thinnest of paper the required pattern or design, and the tracing is then gone over with a composition of lacquer varnish and vermilion, afterwards laid on whatever it is proposed to impart the design to, such as the facing of a cabinet, or other piece of work, and well rubbed over with a bamboo spatula. On the removal of the paper the material below will be seen to have received the outline. This is now gone over with a particular kind of soft lacquer varnish.

When this industry is pursued in hot weather the varnish speedily dries, and consequently, where the pattern is a good deal involved, such as one representing bunches of flowers or flocks of birds, a small portion only of the pattern is executed at one time, and the gold powder, which enters largely into most of the lacquer ware for the foreign market, is applied to each part as it is being executed. For this a large and very soft brush is used, and by its aid the gold powder is well rubbed-in with the lacquer or varnish. The work is then left to dry for the space of about twenty-four hours, after which the pattern is lightly rubbed over with charcoal, made from a particular wood in order to produce evenness of surface. The work is then rubbed with polishing powder, and afterwards carefully wiped. The above description simply applies to the mere outlining on any given surface or ground-work of figures of men, women, birds, flowers, &c. There still remains a good deal of finishing work, such as the tracing of leaves on trees, the petals of flowers, the wings of birds, and so on, according to the particular subject in hand. Into all of these gold powder largely enters, the working in of which requires a light brush and a skilful hand, to ensure an even mixture of the powder and varnish. After this has well dried, a particular kind of lacquer varnish, known as "yoshinô urushi," is well rubbed in, and the whole then polished with horn dust. The polishing process is done with the finger, and is continued until the gold glitter shows out well. A beautiful polish is thereby attained. Briefly, then, the designing on lacquer ware is done thus :—Supposing the subject to be a flower, it is traced out on the paper and imparted to the groundwork of wood. Gold powder is then sprinkled over the work from out of a bamboo tube, well rubbed in with a brush, and then allowed to dry, afterwards polished and a coating of varnish applied. This is repeated several times, until the work assumes a rust-colour. The veins or tracery of the leaves are now marked out with lacquer varnish. Before this dries gold powder is again sprinkled over and then well rubbed in with a brush. When the surface has dried, it is dubbed over with a piece of charcoal, so as to tone down any irregularities. After this it is polished, when the flower appears in due form.

Having spoken of the specialty of pure Japanese industry, we will enumerate some items that exhibit the great advance the people have made by importing knowledge from Europe. They are a self-contained people, and prefer that everything should be made by themselves, even if inferior in quality or design. Hence they eagerly learn how to make everything they have a mind to. In machinery as applied to the arts, they have papermaking works that produce about a ton or so each per day, but at present foreign supervision is employed. The printing papers are entirely of rags, and the packing sorts of a mixture of rags and straw, half each ; and better machinery is already being adopted, to the decay of their old hand-made methods of manufacture.

In the refining of sugar they are very ingenious, but their prejudice is entirely for their own growth. The raw Japanese sugar is supplied from Satsuma, and one of the refineries will turn out five or six tons of loaf a day. Cotton spinning factories are springing up, worked by steam, and are worked at prices which are not in excess of our own exported goods. Knitting machines are regularly bought up for domestic use in the making of under-clothing, shawls, scarves, and stockings, in cotton and wool of all colours ; carpet weaving has been introduced, and the designs are said to be handsome ; they use cotton, jute, wool, and other mixtures such as fibres, with a skill that equals the European. At Osaka is a large manufacture of hats of cloth and straw, or velvet, or silk, after foreign style, and a very thriving and lucrative business it is. One factory turns out 1,000 dozen of hats and caps monthly, and is always full of orders. The curious fact is, that they are imitating the fashions of other peoples, and the goods, equal in shape and finish, the newest fashion, and best makes of foreign countries. In clothing they have adopted modern machinery used in England and America, and so successfully, that the merchant trade in ready-made goods exported from abroad does not pay. They make their own sewing machines, and lately have taken to make glass in the same way as we do, with fair result, and much cheaper than we can. There is scarcely any branch of industry its people do not undertake,—brewing, brick-making, chemical works, railways, gun making, are specially to be named. They seem determined to attack any import trade by rivalling its production both in cost and efficiency.

But for engineering Japan has to depend on foreign aid for the present, until the lapse of a few years will have educated the young men to that profession under English or American instructors. There is a department of Public Works designed to foster and establish means for constructing and repairing every class of engineering work. Mr. C. J. Wilson, A.J.C.E., is the Chief Engineer at Hiogo, an important port, and is carrying on large works there in improving the harbour, erecting buildings, making railways and termini. Now there is a slip of 615 feet in length, capable of receiving on its frame a vessel of 200 feet length and defended by sea wall and masonry piers, running 328 feet out, and of a depth of 30 feet, fitted with cranes and sheer legs. There will doubtless be scope for many years for English engineers, not only with the development of railway systems, but in every form of such works : the natives apply themselves to the industries in preference to the mathematical arts : they produce goods rather than construct works.

And it is a very respectable production both as to its variety and amount. Tea, copper, tobacco, wax, camphor, coal, dried fish, shells, bark, drugs, wheat, paper, sea-weed, mushrooms, isinglass, sulphur, lead, timber, bees-wax, coke, ore, porcelain, rifles, &c., are among the articles sent from Japan to England and other countries, and in their preparation the contrivances we have adopted are rapidly imitated there. The native has little idea at invention, but is of infinite resource as to ingenuity and imitation. With a material prosperity will come a rapid growth of railways, telegraph systems, and road construction, for the want of which Japan suffers enormous losses, and because of which want her mineral and agricultural resources are undeveloped and her commerce paralysed. Young Englishmen, as has been stated, will have to see to this want being met. Their venture would have this advantage above all other places —that the climate is the finest in the world. It is never very cold or hot or wet. Nature behaves herself more orderly there than in any other land.

The reader will be familiar with the methods adopted for preparing the other most important products of Japan, silk, tea, and cotton ; and it is not necessary to repeat what is so well known. Of the native products, flax is one of the most remarkable. We know the graceful elegance of that plant as cultivated here and in Ireland, but in Japan it attains a height of two feet, and affords occupation to a large number of the people.

Japan is indebted to Holland for the elements of civilisation, and the figures of the present artisan population remind one of the pictures we see of Dutch workmen by the old masters. Astronomy, machinery, physic, natural history—except so far as until the last ten years of singular progress—were known in Japan only from the books or the traditions of the Dutch. We fear that the exclusiveness which has impeded civilisation was in former times encouraged by those adventurous, shrewd, western people, for the purpose of destroying the influence of their rivals in foreign enterprise—the Portuguese. If such a condition existed, it must be confessed the Hollander gained but little ultimate advantage, because the clever native knew how to make a mere tool of the people who claimed recognition among them. We see this jealousy carried on even to the present time. The merchant has no political status ; an idea not without its justification, but one foreign to Europe in our days, and one that derived its significance in Japan from a deliberate determination to withhold political power from foreigners.

During the whole of the recent anarchy and strife the skilled workmen and their masters, and all traders, were below what they call "the vulgar," as the latter were below the noble. "Agriculturists, artisans, and merchants," says *The Japan Times*, "are so far below 'the vulgar' as to be beneath mention or consideration. 'The vulgar' is simply the most numerous of the four privileged classes of Japanese society—the others are in the following order :—Tillers of the soil and miners, who raise the produce of the earth and are held to be the original creators of wealth ; artisans, who manufacture raw materials into clothing, arms, houses, and furniture ; and lastly, merchants, the brokers between the producer and consumer, whose toil is lightest, and whose profits are merely an increase of cost." But with the importation of European engineers some modification of these notions are certain. Possibly, the stranger may rank among the learned : he will certainly take a position there which is often denied him here unjustly. He will never cease to be superior to the merchant—"the broker whose service consists in enhancing cost without increasing values."

The Japan Government has always acknowledged the superiority of Europeans in civil engineering. Seven years ago the question of railways underwent vigorous discussion in their Committee on Public Works, the telegraph having been already sanctioned. Drawings, plans, and estimates, all from foreign civil engineers, were submitted to this body, and reported favourably upon to the government ; but the Ministry had no money to spare. In that juncture Mr. Lay, C.B., offered to find what was required if he were granted a concession. He had been Inspector-General of the Imperial Foreign Marine Customs in China, and on his retirement took much interest in financial matters affecting Japanese progress in connection with London financiers. He offered, it is said, to obtain a million sterling from London

if he were invested with authority from the Government and authorised to engage contractors and engineers, in which case he proposed to lay down 300 miles of road through a mountainous country and connect the two capitals. But on further examination it appeared that the former Government promised some American diplomatists, who used their office also for trade, that their country should have the preference in the event of railway enterprises being taken up. The Government in the dilemma became proprietors of that project, and also all future railways; and eighteen miles out of the three hundred were constructed. The telegraph grew more rapidly: many hundreds of miles being under its operation.

Then the mining works of Japan needed the English civil engineer, and will do so much more as the resources of the country are appreciated and can be utilised. Rich mines of metalliferous and other minerals have been worked from the most distant times, yielding gold, silver, copper, and iron of excellent quality, and these undeveloped mines excited the cupidity of early immigrants, who frequently applied for concessions to work them on the foreign-company principle, but without success. The proprietor fancied that what was good for the foreigner was equally valuable to the native, forgetting that in such operations skill had a value that might produce wealth for both when combined. They let the mines to natives, and aided them with capital, but after a while the Government determined on calling in the services of a competent foreigner to be the Mining Engineer, and the position fell to the lot of Mr. Erasmus Gower.

Japan possessed also coal-mines, and much correspondence appears in the official documents on that subject: from which it appears that as large a coal field area exists there as in Great Britain, but the Japanese had only worked the surface. They did not value the contents of the globe at half the rate they appreciated its surface. Agriculture before mining! what were metals and stones in comparison with food and clothing? They only had a little coal mine on one of their islands, and worked that very rudely; but in spite of their ignorance and the obstacles that beset the miners and proprietors, it showed profitable returns.

When this blundering came to be known, Messrs Glover of Nagasaki obtained a concession with great difficulty, authorising them to carry on the operations on European principles. Mr. T. B. Glover immediately opened up a new pit through the lowest part of the carboniferous strata; sunk a shaft to a depth of 150 feet, struck an eight-foot seam as the upper stratum, and found a lower of ten feet more. This discovery happened to offer much advantage to the English Government, whose steam-ships in the East were often in distress for coal, and Sir Harry Parker visited the place. The particular speculation did not fulfil the expectations excited, but enough is known to make this word of Mossman's a pass-word: "The coal and iron fields of Japan will make it, in that respect, the Great Britain of the East."

The iron of Japan makes finest hard-steel, and there is no wonder that when light-houses were wanted, requiring that material, advantage should be taken of the services of Messrs Brunton and M'Vean to superintend all works of that description. Work-shops, and dwelling-houses were erected for the British workmen, who brought the apparatus from Milne's of Edinburgh, being skilful and able to direct the native workmen in the general manufacture. The inferior works called forth successfully an ingenuity and finish worthy of comparison with anything from England; but they knew nothing of the idea belonging to the engineer, nor exhibited any resource warranting the belief that foreign aid can be dispensed with for some years to come, in that branch of human power and thought. Their manufacture of a light-ship ready for its lantern, and a number of large buoys, was a creditable and hopeful beginning in a department of manufacturing utility, but there is no apparent ability of invention, or a profusion of general resource.

There can be no doubt that the Japanese will try his best to overcome this deficiency. The government has entered on a course of enlightenment, and will not be likely to turn back. In 1868 the most skilful artisans in metals, and those who showed any capacity for engineering, were set to study the steam-engine and other foreign machinery, for which drawings and plans had been obtained, and a school for draughtsmen set up. These drawings and models enabled them to comprehend the theory, and to acquire a particular knowledge that qualified them to superintend the making of small marine engines and small locomotives. This has grown to such an extent as to produce an Imperial College of Engineering for students who pass a competitive examination, which college is still under the management of English professors. In it are well fitted laboratories and various work-shops. The curriculum includes civil and mechanical engineering, telegraphy, architecture, chemistry applied, and metallurgy. Bessemer will soon be represented there in his furnaces and machines, in common with the mechanical inventors who have arisen or become great through the great development of the capabilities of iron ore which have been created by his process.

Pottery is an art belonging both to the ancient and modern history of Japan. The old has its renown, and the new its character. These are made in their finest forms, of the same China clay as have been all the fine pottery of the world, whether in Persia, China, Japan, Germany or England; and this gives a lucrative employment to large numbers of the population.

Twenty years ago darkness spread itself over the land, but now its rulers are holding out to the people the light of European civilisation, dispelling that ancient oriental and inscrutable darkness. The barriers of exclusiveness are broken, and several seaports are opened to the merchant fleets of every nation. The monarch claims dynasty, with all its responsibilities, friendships, and alliances. The relations of the classes of society have changed from the code of servitude and tyranny to an imitation of the west, for which once they had nothing but scorn and contempt. The outcast despised foreigners are now the cherished friends of Japan; they may take their share in politics and state service; they can be trusted with national defence, and their nationalities are welcome in all waters. The example, teaching, and service of the Dutch have done all it could, and has passed away. That exclusive policy has ended in the exclusion of its authors. Holland outbid Portugal in the race of monopolising the affection of the strangers, and won; but now, she has no occasion for supremacy; instead of her, a dozen nations have their representatives, and a dozen more may come. Human life is sacred and safe on the highway and on the sea, and if the adventurous European can bring his capital, his brains, his experience, or his inventions, he is welcome in every sense; protected in every way; and certain of better reward, and more than can make happy the life of man, than he could find in the Celestial Empire or in any other foreign ground whatever.

SPECIAL EXHIBITION OF MACHINERY EMPLOYED IN DOMESTIC ECONOMY—VIENNA.

THE Society of Manufacturers and Commerce of Lower Austria, in connection with the Council of the Corn and Flour Exchange at Vienna, have held an exhibition in each of the two past years of such products of mechanical skill as were connected with machines, apparatus, and implements used in flour mills, bakeries, breweries, distilleries, and generally in the corn trade. The show is held at an appropriate season—the Annual International Grain and Seed Fair—and has hitherto been attended with most favourable results. Nor need we be surprised that such should be the case. Exhibitions which display works of art are deservedly popular because they afford pleasure and recreation; they also exercise a refining influence throughout the whole community. If this be the case in what may be be said without disparagement to be the useless—that is, non-productive arts—how much gain may we anticipate from a display of the numberless and varied specimens of works constructed by machinists that are designed to economise the drudgery and augment the facilities of operations that belong to human support. If, for crude methods, those of science are substituted; if quantities cease to be taken by rule of thumb, and accurate formula is practised; if one hour of precious time can include the hitherto labour of six; if ease take the place of toil, rapidity that of weariness, brightness that of monotony, and the deadness of mere human struggling gives place to the suggestiveness accompanying all machine inventions; if the drudgery of meeting the ordinary necessities of human nature is transformed and made a pleasure,—a work of high beneficence and advantage is thereby accomplished. Bread-making, brewing, and liquor-making are indispensable; but they are so much loss in the human life except for the strength they ultimately supply: any method which shall decrease that loss of time and substance is so far a priceless gain.

The memory of every intelligent observer will furnish evidence of the contrast between things present and past, concerning all these domestic operations. Changes have been so rapid as almost to be unfelt. Machinery laid upon these departments its invincible hand, and private house-to-house brewhouses and bakehouses disappeared as if by magic. But machinery has taken another step. Factories have the fatality of indefinite

expansion, and in the end become more expensive than when they began. It is very nice to have the same standing charges, and produce increase of work by good management, but when the tide of expansion sets in, there arises another tide which, before it retires, will tell another tale. The ratio of profit ceases, and the big house finds that the little one can cut him out. Hence has arisen innumerable examples of ingenuity such as belongs to the machinist, producing small specimens that can be employed in private dwellings, or in a small way; and it is affording relief and pleasure in thousands of houses by a quiet adaptation of the best of modern inventions to the ordinary requirements of a domestic residence.

Exhibitions which have for their object the extension of the domain of science and mechanics into the most familiar places where human life has sway, are deserving of regard much more than is generally felt. That at Brussels last year on sanitary matters, and the education associated therewith, made no pretensions, but it has given impetus to a series of changes most conducive to the progressive happiness and longevity of the community. This at Vienna will, it is to be hoped, year by year, do the like good in regard of the supply of human wants, as that at Brussels did in protecting man from contingent ills.

The active and increasing interest hitherto shown in these Special Exhibitions encourages the hope of a larger participation in the Exhibition arranged for the present year. Exhibitors will have a most favourable opportunity of showing the articles of their manufacture to a large number of experienced men; since besides the numerous active participators in the International Grain and Seed Fair, which last year numbered above 5000, the Exhibition will also be attended by the members of the Association of Austrian Millers, the Annual General Meeting of which will take place at the same time, as well as by many members of the Association of German Millers, a meeting of which will be held a short time previously at Nuremburg, and to whom a special invitation to attend the Exhibition and Fair as a corporate body has been sent.

These Exhibitions have also a great influence for good by alluring individuals to knowledge and to action. A man sees one of the simple modern contrivances for brewing, and forthwith thinks it would be pleasant to brew; but he knows nothing about it, and must learn. He soon ascertains the nature of the water in his district, and that leads him to determine the quality of beer he ought to select: he then learns the proportions of malt and hops. He learns about boiling and working and fermenting, and his thermometer becomes a nearer friend than ever the weather could make it. He wants a small quantity, for it is only domestic brewing, and learns the importance of exactitude and the danger of wrong proportions, and at the end of his little purchase of proper brewing tackle and his fine novitiate in the art of brewing, he comes off with 20 gallons of good sound honest beer at the end of a fortnight.

Just so is it with baking. Residents in the country are by modern appliances invited to return to rural habits of the past, when the greater part of the household wants were supplied by the consumers themselves. The neatness, and lightness, and delicacy manifest in the patterns of the apparatus used in bread making, tempt one to recommend the mistress to experimentalize in that manufacture and to learn how bread is actually made and what are the ingredients. He takes his half bushel of flour and treats it artificially by warming, salting, fermenting, and baking; and in three hours, there is his bread hot and wholesome before his eyes.

We might thus discourse on all the various items which compose the place we call home. Wines, fruits, and all the variety of products which make up the comforts of a residence so far as the interior is concerned can be made "at home in future;" the least attention and care will suffice and the reward of the toiler vindicated. But he must have all the details properly attended to, which cannot be assured unless by an actual examination, which examination can only be by contrasting one aganst the other.

The avowal that this scheme is indeed depending for its success on the fact that it is a market, ought to be no disparagement. There is in such an arrangement a positive advantage from the facility it provides for selection and comparison, and the acquisition of knowledge through interrogatories. As it does not take place until August, there is time for making such arrangements as shall combine holiday and comfort in one outlay; while for exhibitors there is time to apply for space, which is provided at a most moderate expense, and to arrange for shipment and reception.

Exhibitors are supposed to know their own business, and they most certainly do. They are the life of exhibitions and the instructors of mankind. The market, as it is called by the good Viennese, is just the place where the wanting race can find its satisfaction, and the ignorant miserable obtain his desire.

ELECTRIC LIGHT.

PUBLIC attention is again called to the subject of utilizing electricity in the illumination of large buildings and ships; and as a contribution to the general knowledge, it may be acceptable to recite the course of invention as far as it has proceeded at the present time. That may lead us to observe once more how much we gain unconsciously from predecessors, and how little each individual can claim of the honours of invention and discovery. The recent experiments at Paris and in London, grand as they are, and hopeful for the future, are but the latest growth of what has preceded; just as, in the case of the electric telephone, almost every idea and principle is to be found in Sir Charles Wheatstone's specifications of patents; ideas left because other objects and pursuits engrossed the inventor's time and thoughts; so is it with the knowledge now occupying the general mind concerning the light derivable from electricity—called Electric Light.

Sir Humphrey Davy, about the year 1813, discovered the convective discharge between charcoal or carbon electrodes, called "the voltaic arc." The galvanic battery of the Royal Institution, consisting of 2000 pairs of zinc and copper, each having a surface of 32 square inches, and charged with acidulated water, was used to produce the phenomenon. The discharge took place through more than four inches of air and six or seven inches of vacuous space. "When any substance was introduced into this arc, it became incandescent; platinum melted in it like wax in the flame of a candle; saphire, magnesia. lime—all the most refractory substances,—entered into fusion. Fragments of diamond, points of carbon and of plumbago, disappeared rapidly and seemed to evaporate in this focus, without appearing to undergo previous fusion." Many experiments followed, conducted by different individuals and with varying fortune, until in 1848 M. Foucault constructed an electric light apparatus, in which the luminous point remains fixed; to effect this, the carbons are moved by clock-work, which is liberated by the armature of an electro-magnet included in the electric current. M. Breton's apparatus was similar, but instead of springs for approximating the carbons, weights and counterpoises were used; there is also a ratchet wheel and click movement instead of a detent employed to maintain the separation of the electrodes. But M. De Moleyns had published certain improvements in the production or development of electricity, and the application of electricity for the attainment of illumination and motion; relating to the battery; the means of generating light by constantly supplying the electrodes at their junction with "pulverized charcoal" from a tube in which the upper electrode was enclosed, which electrodes consisted of platinum wire of suitable thickness, the lower one enclosing a piece of spongy platinum; and by various contrivances in connection therewith.

Nor should Mr. Wright's improvements in 1845 be overlooked; they consisted in a method of producing a permanent light by continually presenting one or more fresh points or surfaces of carbon or other suitable material to the path of an electric current. This was effected by sending a galvanic or other electric current through circular discs of carbon, mounted upon axes revolving in bearings attached to a non-conducting frame, and adjustable at various distances from each other; or a separate current sent through each pair of discs; and by suitable wheelwork connected with a weight or other prime mover causing the discs to revolve with a slow and uniform motion. In order to bring about the desired effect, two neighbouring discs connected with opposite poles of the same battery were brought into contact, and as soon as the points of contact were sufficiently ignited, the discs were withdrawn out of contact, and a brilliant and permanent electric light was evolved. A ground glass globe, or system of mirrors, could be used to diffuse the light equally.

This was followed, in the following year, by the invention of Messrs. Staite & Gardner for effecting the illumination of public and private buildings, streets, squares, and other public places, by means of solid prisms or cylinders of carbon enclosed in air-tight vessels of glass, or some other transparent substance, and ignited or rendered luminous by currents of voltaic or magnetic electricity, which carbon was specially prepared. Platinum also could be employed. In 1849 Mr. Staite, in conjunction with Mr. W. Petrie, improved all the instruments and apparatus, and set forth better methods of their application to lighting purposes.

To enumerate the many steps or gradations would be wearisome to the reader, and contribute little to the

reputation of the inventors because of the subsequent improvements; but it is impossible to overlook Mr. Faraday—one whom we have but recently described, and whose work and character will never be forgotten. He lectured at the Royal Institution on March 9, 1860, upon Lighthouse Illumination by the electric light, and pointed out the great adaptability of that agent for such purposes on account of its great compressibility.

The most recent improvement is that patented by M. Jablochkoff referred to above, and it bids fair to become a satisfactory advance upon all its predecessors. The test examinations have been made; the first did not go off according to the design of the inventor, but the second did, and the company present saw the possibility of its acquiring public favour for lighting public buildings, illuminations, and docks. The apparatus used for the occasion consisted merely of an electro-magnetic machine worked by a small steam engine, some insulated wires, and the electric candles, which are the invention of M. Paul Jablochkoff, Russian engineer. It is composed of two carbons placed side by side with a slip of insulating substance between them, which burns away with the carbon exactly in the same way as the wax of a wax candle is consumed with the wick. The light thus obtained is not accompanied by those irregularities which have hitherto formed part of the electric light, and which are the consequences of the constantly varying of the voltaic arc occasioned by the movement of the carbons and regulators. One of the principal features of M. Jablochkoff's invention is the divisibility of the light, it being possible to burn several lights with a single current of electricity. In lighting up a building with the electric candle instead of gas, a magneto-electric machine would take the place of the gas works, and telegraph wires would be substituted for gas pipes. With regard to the question of cost, it was stated that it was considerably less expensive than gas.

The second and most successful series of experiments on Mr. Jablochkoff's electric candle took place at the West India Docks before a select company of leading electricians, engineers, and scientific men.

The first experiment was the lighting up of a large open yard, some 75 yards long, by 50 yards broad, with four candles, each giving out a light equal to a hundred gas lights. The candles (which we have already described as consisting of two slips of gas carbon placed side by side, and separated by a strip of kavlin), were mounted on four lamp posts about 15 feet high, and were covered with opal glass globes that softened down the intensity of the light to a pleasant mellowness. These four lights were sufficient to illuminate every corner of this large space, so that diamond type could be distinctly read at the farthest distance from the light that it was possible to get. At first the light was somewhat dull and unsteady, but as the machine seemed, so to speak, to warm to its work, the light became more brilliant and almost perfectly steady. After about twenty minutes the electric lights were turned off, and four large gas burners of four lights each, were turned on to show the contrast between the brilliant whiteness of the electric light and the smoky dulness of the gas.

The company then mounted to the top floor of a warehouse close by, in order to witness some experiments on colour. The aim of their experiments was to test the possibility of using the light for sampling different kinds of produce, &c., on dark days or at night. Unfortunately the lights were placed horizontally so that the strong shadows cast by each individual grain, of such commodities as grain, pepper, coffee, &c., interfered so much with these colours, that this part of the trial must be looked on as left in abeyance. Several experts, however, gave it as their opinion, from what they had seen, that had the lights been placed vertically, they could have carried on their sampling operations with perfect ease. The effect of the light on coloured fabrics was next tried, and both experts and outsiders were unanimous in declaring that the effect produced was little short of daylight. At night and on dark days, there are certain colours which cannot be distinguished, very dark colours looking black, and very light ones white. Under the electric light, however, dark navy blues, olive greens, plum colours, and pieces came out in their natural tints, while the patent creams, straws, lemons, and greys, were perfectly distinguishable from each other and from pure white.

The quay and ship's hold and deck were next most successfully illuminated by a couple of the candles, one of which was carried up and down the quay, thence into the hold of the vessel and along the deck from stem to stern, showing its perfect practicability for loading or unloading cargoes by night.

The last experiment was with M. Jablochkoff's latest form of candle, in which he dispenses with carbon altogether, except as a priming, as he calls it. This candle consists of a thin slab of porcelain about as large as half a visiting card. The electrodes leading from the machine are fastened along the opposite sides of the porcelain slabs, the wires projecting slightly beyond the top of each of the slabs, which is fixed in an upright position. When this candle is to be lighted a slip of pencil lead is laid on the upper edge of the porcelain slab so as to connect the two poles. The current passes through the lead, which becomes incandescent and melts the porcelain. The melted porcelain being a conductor the current passes through, causing it to glow with a brilliant but peculiarly mellow light. The porcelain vapourises but slowly, a slab an inch wide lasting for twenty-four hours. The flame given off by the porcelain seems much steadier than the carbon light; indeed, it was difficult to discover anything beyond a very slight occasional flicker.

The machine used was made by the *Alliance* Company of Paris, and contains 32 horse shoe magnets of six plates each. It was driven by a small portable agricultural engine.

M. Jablochkoff's estimate of the cost of the light is as follows. The four candles require a two horse engine, working at the rate of 2d per hour, and consume a length of candle costing 1s 2d, making 1s 4d per hour for the total cost of the four lights, which are equal to 400 gas lights, costing in London 5s per 1,000 feet.

If M. Jablochkoff's figures are correct, it will be seen that the electric candle is less than a quarter the price of gas. Whether these data are correct or not, M. Jablochkoff may be congratulated on having proved beyond any sort of doubt, that it is perfectly possible to have an electric light which is far superior to any that have gone before it, without clock-work, electro-magnetic springs, or any other expensive and complicated machinery, and that one source of electric power may be distributed amongst a series of different lights with as much ease as ordinary gas is conveyed to a number of burners.

CEMENTS AND CONCRETES.

WITHOUT intrenching upon the province of our contemporaries devoted to the Art of Building, by entering into discussions on the relative merits of various materials or practices, we believe that a general allusion to the subject will not be deemed inappropriate or be found unacceptable.

It has long been the fashion among superficial persons to hold stucco or artificial stone in contempt; to scout it as an hypocrisy; and to believe that its duration is of the most uncertain term, except that it will soon perish. There is nothing in fact that justifies so wholesale a condemnation. None can doubt that the art of making a substitute is liable to abuses, because, itself being an imitation, it can also be imitated; and in proportion to the success of the early experiments would be the eagerness of competitors to secure contracts by accepting engagements at prices that would be unremunerative to the honest man, and for the time imperil the success of his enterprise.

But while there are varying qualities in cements and concretes, it must not be forgotten that stone has by no means any claim for uniform quality. Probably there is no substance of such infinite variety; and few that at one time or the other have more disappointed those who trusted it. Hence have arisen many inventors, whose labours have been concentrated on devising schemes of preventing decay, or for restoring what time has so ruthlessly and injuriously destroyed. When we come to notice the matter more minutely, there will not be any difficulty in believing that the artificial ought to be better than the natural, when all the processes and materials have been truly and faithfully employed.

In our young days the Roman cement had most of the public favour, and of the kinds that of Parker commanded the highest price. Stucco had become adulterated to an extent that seemed likely to cause its expulsion from the Catalogue of Building Materials; the public gained by the introduction of something which must be used in given proportions, and, as a consequence, the compound rose to the highest point of value, and obtained public confidence.

But the composition known as Portland Cement outran the Roman in public favour, especially for building purposes, because the mortar formed by it, when mixed with sand, presents the appearance of stone from the Portland quarries; and it gained a further preference as an outside stucco, in that the colour to which it dries, is sufficiently agreeable to the eye without any colouring wash, whereas the Roman or Parker's had a dark and dirty tint requiring paint or colouring to render it tolerable.

M. Vicat, an eminent French chemist, is supposed to have been the discoverer of Portland cement, and this good fortune

came to him from having had his attention called to the public interest excited by controversies about mortars, concretes, and cements. He wished to end them, and determined proceeding synthetically to compose hydraulic limes entirely by burning different mixtures of common line, slacked spontaneously with clay. . . . . All the clays which were rich and soft gave the same result. He persisted in this line of experiment up to 1817, during which Mr. St. Leger, an independent student in Germany, had been doing the like. The French chemist's knowledge brought about some small works at Mendon, but with imperfect apparatus and materials. In England, likewise, no serious attempt to found a commercial enterprise appears to have been made, until Joseph Aspdin, "of Leeds, in the County of York, bricklayer," took out his patent, entitled "an Improvement in the Modes of Producing an Artificial Stone," and started some works in 1825 at Rotherhithe, from whence, by reason of his success, he went to larger and more suitable works at Northfleet, where the best material for his manufacture abounded. These works are now expanded into the extensive concern of Messrs. Robins & Co.

Aspdin must have been an intelligent observer to have applied his knowledge of a common remedy for a damp floor, and make it the basis of a most extensive trade. Every bricklayer or house repairer is familiar with the use of road scrapings for paving cellars, especially if mixed with a little cement, and this must have been the foundation of what is now a fine mechanical and scientific operation. He says in his specification, which is now before us, "My method of making a cement or artificial stone for stuccoing buildings, water-works, cisterns, or any other purpose to which it may be applicable (and which I call Portland cement) is as follows :—I take a specific quantity of lime stone, such as that generally used for making and preparing roads, and I take it from the roads after it is reduced to a puddle or powder; but if I cannot procure a sufficient quantity of that from the roads, I obtain the limestone itself, and I cause the puddle or powder, or the limestone, as the case may be, to be calcined. I then take a sufficient quantity of argillaceous earth or clay, and mix them with water to a state approaching impalpability either by manual labour or machinery. After this proceeding, I put the above mixture into a slip pan for evaporation, either by the heat of the sun or by submitting it to the action of fire or steam conveyed in flues or pipes under or near the pan till the water is entirely evaporated. Then I break the said mixture into suitable lumps, and calcine them in a furnace similar to a limekiln, till the carbonic acid is entirely expelled. The mixture so calcined is to be ground, beat, or rolled to a fine powder, and is then in a fit state for making cement or artificial stone. This powder is to be mixed with a sufficient quantity of water to bring it to the consistency of mortar, and then applied to the purposes required."

The method thus described had a run of fifty years,—a good testimony to its inherent soundness. The banks of the Thames are now studded with large firms, devoted to the production of Portland Cement, and one of them has works that extend over 70 acres of land, in which are seven miles of tramways. Aspdin had no machinery surpassing a limekiln; this factory has machinery driven by engines of 1500 horse-power. Aspdin put his cement into sacks, and not many of them; but now this firm uses up 7½ million of staves for casks, independent of a large trade in sacks. They use of fuel every year 55,000 tons, and keep afloat seventy sailing barges, besides giving freights to colliers and others. Of course, there is no longer a patent, and works of this kind abound. We do not name them, nor is it necessary. The process is pretty much the same. Mr. Reid says, "When the article was first made in England, the original makers maintained an air of mystery in their operations, leading the public to believe that certain peculiarly-gifted individuals were alone possessed with the necessary knowledge of the principle of manufacture." This is not accurate. The patent has expired; and those who work the ideas we have quoted from public documents of 1824 must work as competitors, none of whom have priority in skill, or desert, or knowledge. The result depends solely on their business capacity, and the wise application of sufficient capital. Aspdin formulated practically all their proceedings.

But a notice of the existent condition since the application of machinery seems to be imperative.

London supplies the greater part of this article, having local advantages as to material, locomotion, and distribution. A Cement Manufacturer depends on Chalk, and must set up his works where that is abundant, because it forms two-thirds of his raw materials. Then he must have coal and clay. Now, it happens that in the London district chalk and clay are obtainable at the smallest cost, while the proximity of the enormous gas works causes a supply of coke vastly greater than could be obtained elsewhere. Hence Portland Cement Works are almost confined to the borders of the Thames. The trade with Newcastle enables that town to compete, because chalk can be sent back as ballast to returning colliers, but it is a competition that just admits the northern port to sell in northern towns at equal rates by saving freight charges from London.

The materials being collected, we will trace the operations. First, they have to be mixed, and that can be effected by various instruments or machines, such as harrows and cutters, or by the wash-mill, which requires a horizontal 8-horse engine, and can turn out nearly 50 tons a day. It has special fittings, and requires careful attention. The knives break, because of the flint stones in the chalk, or the stones in the clay; the machine clogs, or the material is not well mixed, or perhaps, the kinds of material have not been put together at the exact condition, or of the exact quality required. A maker must acquire a fair knowledge of physical geography, and as much as possible of the geological conditions that surround him. The manufacture is necessarily carried on in a seclusion from the outer world, when such knowledge is acquired, because the little secrets of the strata enable the maker, if he is intelligent, to outdo his neighbours, in some particular quality, compounded from material he has the sole control of, and the sole acquaintance with. This technical knowldege is of much more importance than even the chemical. Good results are not to be secured by chemical operation on bad material; the basis must be carefully selected, and of the best natural quality; then, if they are treated properly, it is highly improbable that disappointment will ensue.

The analysis of good cement exhibit the following components :—

Chalk from	50	to	65	per cent.	
Silica, ...	10	„	25	„	„
Corundum, ...	.5	„	10	„	„
Oxides of iron, ...	.4	„	10	„	„
Magnesia, ...	.1	„	4	„	„
Kali and Natron, ...	¾	„	4	„	„
Carbonic Acid, ...	½	„	3	„	„
Sulphuric Acid, ...	½	„	2	„	„

It is the practice to prepare samples of the known qualities in the trade before making large quantities, for good reasons. If the compound be accurately proportioned and carefully mixed for a small quantity, there is a certain knowledge acquired by that experiment of what is necessary for a large manufacturing operation. The sample is cheap, and if it fails for its original design it is good for something else, whereas a mistake in a bulk of goods might cause commercial inconvenience.

Chemical knowledge is nevertheless important. It often occurs that a natural imperfection can be remedied by the infusion of chemical ingredients, such as sodas, or magnesia, or alkalies.

Two kinds of kilns are employed for burning the bricks. The one for samples is small, and the other large, according to the extent of the works. The little one tests all matters applicable to the larger, such as the fitness and worth of the fuel in hand, the amount of heat, and the lime required in burning, and the space that a quantity of certain ingredients will need,—for the bulk varies according to the quantity of water in the natural state.

There are two methods of preparing cement, the wet and the dry. By the wet, the chalk, marl clay, and other ingredients, are mixed with water and thoroughly commingled when it settles down and drains itself. By the dry, the materials are powdered in a dry state, and then mixed with water. Both have their advantages and disadvantages. It is, however, obvious that the wet method is not applicable to lime-stone, clay iron-stone and phonolite : these must be previously crushed and ground.

Drying is effected in a fire-brick building, heated to 100° centigrade, having openings at the top and sides; when the chalk is put in, the door is closed and stopped up with clay; the fire is kindled, and the work is quickly done. The other materials should also be dried.

But the pulverizing of materials so dried requires machines of great power, and even then one is not sufficient. Blake's, of which we have spoken, is the first. The late Mr. Marsden of Leeds, held the patent for England as partner with Mr. Blake, and has improved upon it several times. Since the patent expired, other engineers and those of Germany have constructed them with improvements, notably Sieves of Kalk. We insert a drawing of one of the best. They are tremendously powerful, being invented for the purpose of stone-breaking for roads. They now are adapted for crushing to the finest powder any kind of stone or flint; and at the present time, blocks of 20 in. circumference, or pieces of the size of a nut, can be pulverized, especially with the aid of the edge runner, which is a vertical mill for small pieces.

When the materials are prepared, they are worked up into

bricks by the aid of a forming or moulding machine, at the side of which is an iron alkali vat, containing the proper proportions of burnt chalk and soda. Into the forming machine are put alternately one measure of powdered cement, and one measure of the vat fluid until it is full. The shaft is in motion, and women attend to receive strips of cement as they exude from the machine on to drying boards, where it is cut into pieces of 5 in. breadth. Being hot, these bricks soon dry, and are removed by hand to iron plates, 4 ft. in length, and 10 in. broad, which, when filled, are sent on to the drying channels, which are heated by fire. Every channel will hold about a dozen waggons, each of which has six stages; these each hold three drying-plates, containing twenty-seven bricks, making a total per waggon of 162 bricks. In drying, these lose half their bulk, and weigh about 4lb each. The channel, when full, contains therefore 2000 bricks, weighing 4 tons. Thence a tramway leads to the endless kiln, taking one parcel up and another down.

These burnt clinkers have to be ground, and for that work the same number of mills are necessary as for grinding the cement, 1st., the stonebreaker; 2nd., the vertical; and last, the horizontal mills.

Of qualities, a few words are usefully offered:—Colour is really of no moment, but there is a general fancy for those of the greenest-grey tint. It is easily made of that hue by watching the burning process as to oxidization.

Weight is an uncertain test of quality; but it is a test. Some foreign sorts weigh less although fine, and it is difficult to imagine that finely-ground goods should weigh less than those coarsely ground, provided the quality be equal.

Cement is like arrowroot in this way; if it be good a little water makes it of service; but if it has not been properly harvested matters do not go right. It must not be over burnt, or long warehoused, or have been kept alive by damping or by acids. The best cements are those that absorb the least quantity of water, and when they are used with sand the same proportion will be maintained. Besides these comparatively water-tight cements are of the best, the choicest. Notably, White's English completely eclipsed Vicat's French at Havre.

Again, it is useful to remember that these slow absorbing cements cannot be fermented to heat as if they were lime. Common qualities do; but what of it? They crack as soon as they are cold, or fall to pieces on the first atmospheric change.

You can test cement by the hardness it acquires under water, and by contrast the qualities of hardness that ensues from exposure. Try the experiment by putting one piece a fortnight under water and dry it and take another 24 hours in the air: rub them together and you will soon see which is the hardest by observing which first goes to dust.

In this paper we have availed ourselves of the labours of M. A. Lipowitz and of Mr. Reid, while differing with both of them. The advocacy of the use of Portland cement could not be in more capable hands, and no one who pretends to any knowledge can question the superiority of that to all other species or varieties. Still we have not reached as yet the limit of quality in adhesive material that can be artificially made. There is no doubt that we shall have artificial stone or mortar more strong and enduring than all the bare products of nature.

Our illustration is of one of the best that are in use, which is Mr. H. W. Marsden's, of Leeds, already mentioned, and are reported on most favourably. They are in use at most of the principal copper and lead mines, and the cement works in England and on the Continent, and remarkably in America. They have economised cost and improved manufacture to an extent that can hardly be computed.

Breaking ores or stones down required a tremendous amount of labour, which is saved by the use of Marsden's machine, and the work better done.

There is, too, a lately patented and decided improvement in them, designated the New Patent Reversible Crushing Jaw, by the use of which the old jaw, when worn out, can be replaced in less than half-an-hour by any unskilled workman. This is of the utmost importance. The jaw is now made in sections, and can be turned end for end; besides, there is a saving in cost in having only to substitute a comparatively light casting in place of the old weight of metal. Cement making has been improved a hundred-fold by the introduction of this machine, and the whole phase of each manufacture, as it may be changed in the future, will only conduce to increase the demand for and the estimation of the machines introduced here by one who, from being a Leeds boy, went in his humility and necessity to America, and there found appreciating friends. Returning, he brought their confidence and trust. He was joint-partner and English Agent; he became Mayor of the town he left when a needy boy, and Leeds or England will not lose sight of the maker of Blake's machinery.

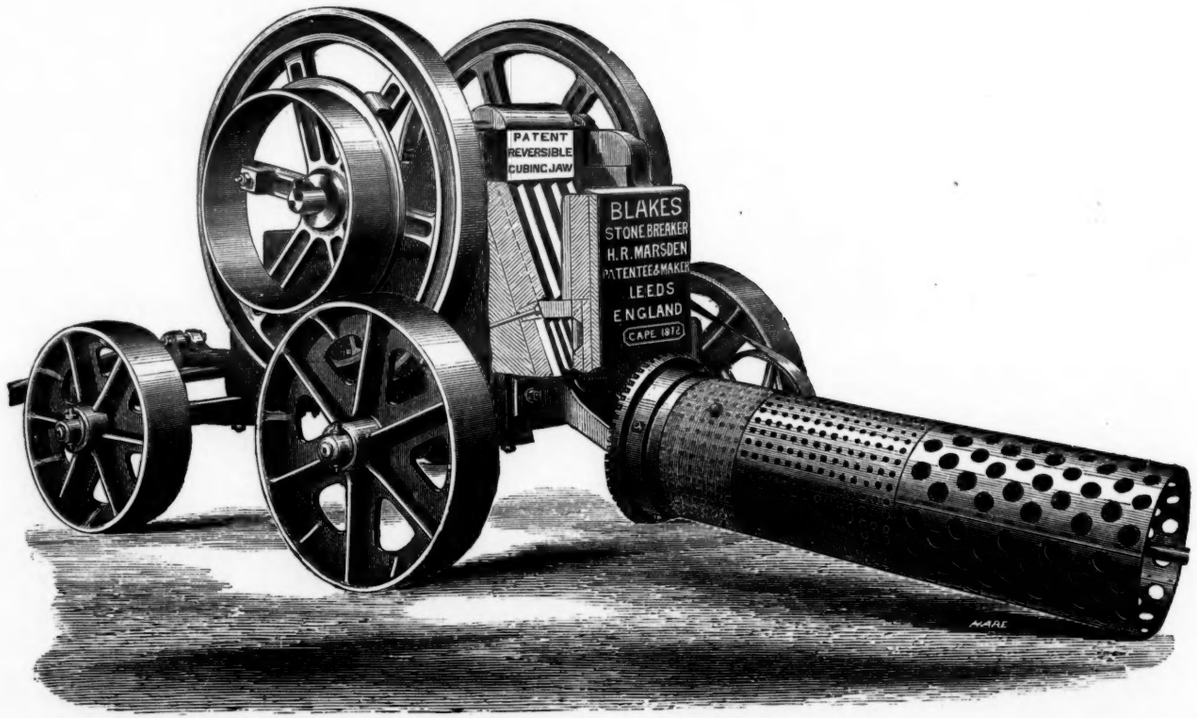
TRAMWAYS WORKED BY STEAM.

THE English Parliament issued a Royal Commission in autumn last directing certain gentlemen to make inquiries and collect evidence, and examine personally the many projects in connection with this apparently inevitable necessity, in order to avoid what was avoidable of mischief or error in the legislation that must ensue.

The agitation is not confined to England. It has for many years been operative in America, and the conclusion is not reached. It has been the source of many experiments in France, and the results are in many respects favourable to the innovation; and in some adverse. It has been employed in less compact communities and districts most advantageously, and there can be no reasonable doubt but that all the difficulties which beset its practicable working will ultimately be overcome, and the steam car not only run on the tram but on the road.

In our November and December numbers we noticed the labours of Messrs. Merryweather and also those of the French engineers. In England Mr. Hughes has sought to rival Messrs. Merryweather, and the Continental Powers have displayed more interest in the question than it has produced at home. Russia, Germany, New Zealand, Paris, and several other great localities have given orders to the Long Acre firm, and none of them complain at the result. The Danes, always eager in ingenuity, although so small a nation, issued a Commission, and the report of these Mr. Rowan of Copenhagen has translated into English. It is thus summarized:—The conditions to be complied with by a mechanical motor on street tramways are: (1) That it must be more economical than horses; (2) It must have more tractive power than two horses, for these can only draw on a level forty or fifty persons, while a carriage with mechanical power must, to be economical, accommodate many more; (3) It must be capable of being stopped almost instantly; (4) The engine must cause the passengers no inconvenience whatever; (5) The engine must not be too heavy or occupy too much space; and (6) It must be so arranged that the engine-man can at all times, without stopping the car, have access to any part of the machine, and have a full view of the road on which he is running. Steam or air power possesses no advantage whatever for use on tramways over horse labour, except economy. It may be taken as an axiom that unless the cost of any system of mechanical traction is less than that of horse traction, it cannot live. As regards the second proposition, opinions may differ. Plenty of power must be provided, and toy engines can never be relied on to work tramways. The third, fourth, and fifth propositions will be generally accepted as sound without dispute. The sixth is no doubt right, but, at the same time, it is, we believe, quite possible to build engines which will work well, although they are no more under the eye of the driver than is the machinery of a railway locomotive.

Mr Rowan's view are in many respects identical with those which we have repeatedly expressed, never more so than when he explains that separate engines, weighing not more than two tons, are of no use on tramways, because they lack adhesion. For this reason he is opposed to the use of separate engines—as, for example, Mr. Hughes' system—and he points out that such engines must of necessity weigh at least five tons, most of which is dead weight, while the boiler and engine alone need not weigh more than two tons. But three tons of non-paying load to be hauled represent a serious item of expense. He proposes, therefore, that the engine shall be combined with the tram car in a very ingenious way, which we shall proceed to describe. His tram car is of unusual length, and supported at each end on a four-wheeled bogie. Such cars have been used in the United States with great success. The leading bogie, if we may so term it, really constitutes the foundation of a small engine and boiler, the bogie wheels being all drivers, and carrying, in addition to the weight of the boiler and machinery, half that of the car. It is urged against the conbination of cars and locomotives in this way, that when one breaks down both are disabled. To obviate this objection the Rowan car is so made that it can be readily detached from the engine, which is then available for another car. We have not space to give the details of this arrangement, which is extremely simple and ingenious. The engine is quite cut off from the rest of the car by a partition. The car should always be run with the engine first, and to effect this either a turntable must be used, a reverse curve, or one bogie being blocked fast the other can be brought crosswise under the


PATENT
REVERSIBLE
CUBINC JAW
BLAKES
STONE BREAKER
H.R. MARSDEN
PATENTEE & MAKER
LEEDS
ENGLAND
CAPE 1872

car and the latter turned on the blocked bogie as a centre. The motive power is supplied by steam, and to prevent smoke only clean coke is to be used. The necessary draught is supplied by a fan, and this fan is utilised to condense the steam in the following way. Under the seats of the tram car are boxes or tunnels, in which are arranged a number of thin tubes. The air is driven by the fan through these tubes, while the waste steam is admitted to the boxes and there condensed. The air, heated to about 200 deg., is then conducted to the closed ash-pan, and so supplies the fire. The condensed steam is returned in the shape of water to the boiler by a pump, and no attempt is made to obtain a vacuum. Such is, in general terms, Mr. Rowan's proposed steam tram car, and, as we have said, it appears to us to be about the best solution of the difficulties which beset the subject yet proposed. There are one or two points, however, which require elucidation. The first is the cost of such a car. And, secondly, we are not clear that Mr. Rowan could condense his steam as satisfactorily as he supposes by the use of cold air alone. We have not sufficient data before us to make the requisite calculations on this point with certainty, but, assuming that his engine worked up to 15-H.P., and used 50lb. of steam per horse per hour, he would have to condense 750 lb. of steam in the same time. It would not be safe to assume that less than one square of foot cooling surface would suffice to condense a pound of steam per hour; consequently, under the conditions stated, 750 square feet of tube surface would be required; this represents nearly 4000 lineal feet of ¾ in. tubing, or say fifty tubes 40 ft. long stowed under each seat of the car. The cost of these condensers would probably be heavy. The estimated expense of working this steam car is given as 25s. per day of fifteen hours. The cost of working the Copenhagen tram cars by horses is stated to be such that a saving of 40 per cent. would be effected by the substitution of steam.

This scheme is supposed to combine the good points of both of our English engineers' systems. Like Mr. Hughes', it can be used for many cars or not, and like that of Messrs. Merryweather, the height of the propelling mechanism may be reduced to a minimum without compromising adhesion.

It is only fair to add that Mr. Rowan has only constructed and worked one of his cars, but it has been perfectly successful. It is 32 ft. long and can seat sixty passengers. The engine is 18 horse-power, with 150 lb. steam, and can take an incline of 1 in 20, or 80 round curves of 45 ft. radius. It weighs under six tons.

ON CONTINUOUS BRAKES.

(A Paper read before the Society of Arts by CAPT. TYLOR, *Government Inspector).*

IT is a singular circumstance in the history of railway construction and working that the power of propelling trains should have advanced so rapidly, and the means of stopping them so slowly, towards what may be called perfection. Railways are now half a century old. The highest speed became practicable and available within a comparatively short period after their introduction. We were able to travel as fast thirty years ago as at the present day; but we are now, in the year 1877, for the first time seriously considering the best principles for quickly reducing the momentum of fast trains, and we are still depending in the greatest emergencies mainly upon the rude and primitive contrivance of employing men to turn handles in different parts of railway trains for applying brake blocks to the wheels of a few vehicles. This is the more extraordinary, inasmuch as it is more important, for reasons both of convenience and of safety, to be able when necessity arises to reduce than to acquire speed rapidly. It is in consequence of the want of better means of applying brake-power that the signal arrangements have become so complicated, and distant signals have been necessarily placed at such great distances, varying from half a-mile to 1500 yards, from stations, junctions, level crossings, or cabins; with the disadvantages of extra cost, of difficulty and uncertainty of working, of their being placed out of the sight of the signalmen, and of employing electric-repeaters in the cabins to indicate whether the arms are working, and whether the lights are burning. It is from the want of brakes on every vehicle that special brake-vans have been employed on inclines, at increased expense in wages, in wear and tear of material, and in haulage for bringing these special loaded vans up again after their descent with a train. From the want of a larger proportion of brake-power, much time is lost on every journey, the engine-drivers are compelled to slacken speed at long distances from points of stoppage; and the more frequent the stoppages, the greater the time that is consumed. We find that the suburban or metropolitan railways have, for this reason, been amongst the first to make use of continuous brakes. The North London, the Metropolitan, and the District Railways have thus adopted, respectively, the chain brake, the vacuum brake, and the air pressure brake. It is from the want of mere brake-power, properly applied, that most accidents occur, and that almost all the more serious accidents have been attended with fatal consequences. In cases of collision, where engine drivers have several hundred yards, and perhaps half a mile or more, to bring their train to a stand, but are unable to do so from the want of brake-power, the advantages of continuous brakes are obvious, especially on steep gradients, and slippery rails. But they are hardly less important for the prevention of loss of life and injury when trains leave the rails, owing to defects in the permanent way, or to their meeting with obstructions; when failures occur of couplings, springs, axles, tires, or other parts of the rolling stock; and when there are accidents at facing points, or on inclines.

There is no subject so hotly contested in the railway world at the present moment. I have frequently had occasion to observe upon the disadvantages of different companies adopting various systems of brakes, and especially when they formed continuous routes of communication; but I have been told in reply by railway officers best acquainted with the subject, that it would be utterly impossible for the railway companies to agree on any one brake system. Each board of directors has confidence more or less in its own technical officer, and looks at the matter, naturally, through his spectacles. The various locomotive superintendents have, according to their special knowledge, their qualifications, or their experience, honestly formed very different opinions; and they would, I am sure, themselves admit that there is at present no chance of their agreeing together as to any one system of continuous brakes which it would be desirable to adopt in preference to all those other systems. Many of them are, indeed, committed to one or another of these systems; and I have too much respect for them to think that they would lightly change the opinions which they have deliberately formed and confidently expressed.

In other questions of railway construction and working, there are not the same difficulties to contend with as in this. In the construction of engines, or the construction of carriages; in devising instruments for working the block system, or apparatus for interlocking the levers for working points and signals; in applying locking bolts or locking bars to facing points; in the methods of securing tires to wheels, so as to prevent them from flying off in case of fracture; in the form of rails, descriptions of fastenings, construction of bridges, considerable difference may be afforded; and it is a matter of comparatively little importance, how much managers, engineers, and manufacturers may hold diverse opinions, or adhere to differences in practice. But in fitting up engines and vehicles with brakes, other circumstances have to be considered. It is important that in running carriages through from one line to another, they should be adapted to travel together, and that they should be fitted in this respect, not only with the best, but with the same means of convenience and safety as regards the brake apparatus applied to them. This requirement is imperative, and cases of accident will in future be narrowly watched, now that public opinion has become fully alive to the question, to see whether the best system of the brake power is in use, and what has been the result. It may, indeed, be considered certain that the best will before many years have passed become general, if not universal; and that, whether true or not in reference to other matters, the theory of the "survival of the fittest" will certainly prove true in the case of continuous brakes. Before it is too late, therefore, it would be wise for the boards of directors and managers of the various railways carefully to consider this matter, and to ascertain for themselves which is the best brake for general adoption. It is obviously much better that they should come to a general agreement with each other, and generally adopt that which they find to be best adapted for all purposes of practical working and maintenance, than that they should spend money foolishly in adopting a number of different brakes of various degrees of merit on different lines of railway, and certainly better that they should do so themselves than that any sort of compulsion should be exercised by Parliament or by any Government department. I have seen much in the last twenty-four years of genuine, hearty, honest opposition to required improvement, and of such opposition from the highest quarters. But I have also seen how it has disappeared, as a summer cloud, before the teaching of experience, and the force of public opinion. And I know well that in regard to this, as to many other improvements which it has been my duty to advocate, and my satisfaction to see adopted,

fair and open discussion, with public trials and practical working, will brush away premature conclusions and individual prejudices, like so many flies, and cause the best brake, whichever it may be, ultimately to be brought into general use. In discussing the subject in detail, it will be wise to begin at the beginning, and to state what a continuous brake is. In the use of a continuous brake, properly so called, the blocks may be applied from one point to all the wheels of every vehicle in a train, whilst the blocks of the ordinary mechanical brake are commonly applied by a guard on one vehicle only. Brakes may be wholly or partially continuous. They may be so fitted as to be applied along a whole train from one point, or they may be fitted so as to be applied in sections of vehicles; a van, and one, two, or more carriages being coupled together to form each section. If there be broken continuity and several separate sections in a train, then the retarding force in the train will obviously be in several hands, unless there be some further means of applying the brakes on each of these various sections simultaneouly from one point.

Now, the first condition required in a good continuous brake is, that the means of applying it directly throughout the train in an easy and simple way should be in the hands of the engine-driver. It is the engine-driver's duty to regulate the speed, to look out for signals or obstructions, to bring the train to a stand at the required point, and to act with promptitude in any case of emergency; and the principal objects of a continuous brake are, that the engine-driver may have complete control over his train, and may be able to bring it to a stand when necessary within the shortest distance. Having the responsibility, he ought clearly also to have the power of directing the movements of his train, and be able to reduce the speed, or to increase it, at pleasure. Having the first opportunity of seeing danger ahead, he ought to be able himself to use the means of providing against it, and he ought not to be obliged to trust to the guards to apply their brakes, as is now the common practice, in reply to a warning from his whistle. No fact is more certainly established than that the guards frequently fail to hear the brake whistle from the engine, and do not, therefore, make use of their brakes when they are urgently required to do so. In brake experiments, with comparatively short trains, we have known cases where guards and others, specially on the look-out for the brake-whistle, have failed to hear it. The engine-driver should, therefore, be able himself to produce immediate action on every wheel of the train, when necessary, by some process easy to himself, and certain of action. This should be done not merely by means of a communication-cord, which, although it cannot always be relied on even for calling attention, is employed in more than one continuous brake system for acting on the brake-handles in the van, but by the direct application of the forces employed for braking purposes, whatever that force may be; and the guard, or guards, should also have the power, each for his compartment, of setting the same force in action, when it is required—on the failure of any portion of the rolling stock, or a carriage leaving the rails, or other cause unknown to, or unnoticed by the engine-driver. It is not, for many reasons, desirable to afford the means of applying brakes to the passengers; though they should be able to communicate with, and call the attention of, the engine-drivers and guards, if occasion should arise.

As one of the very numerous instances of the want of continuous brakes in the hands of the engine-driver may be cited the accident last November near Wincanton, on the Somerset and Dorset Railway. In that case an up-passenger train for Bath was travelling at a speed of 35 miles an hour, when the leading wheels of the engine left the rails, from a defect in the permanent way. The engine rode thus for 200 yards before the driving-wheels left the rails, but it then turned over on its side, 240 yards from the point of first disturbance. The engine-driver was killed and the fireman and guard, who narrowly escaped with their lives, were severely injured. If the engine-driver had been able at once to apply a continuous brake throughout this train, on finding his leading wheels off the rails, it might have been pulled up with scarcely any damage to the rolling stock, and no injury to himself or any one else.

Another condition, indispensable for a good continuous brake worthy of general adoption, is that it should be automatic in its action, in the sense that the brake should be self-applied on every vehicle in the event of a division in the train. The brake blocks should fly on every wheel, instantly, on the separation of the brake couplings, and this, by direct action, and not through the intervention of secondary means, such as a communication cord. In order that this condition may be properly complied with, each carriage should carry its own store of brake power, and it should not be dependent upon power supplied for any other vehicle, from which it might become separated. The necessity for this condition has been proved in numerous instances. Two of the most serious accidents in this country, as regards the number of deaths, occurred in consequence of the fracture of couplings and the running back of carriages down inclines, those, namely, at Brierly Hill, on the Oxford, Worcester, and Wolverhampton Railway, and at Helmshore on the East Lancashire Railway. And there was a remarkable contrast in two recent instances, the one at Heeley, on the Midland Railway, and the other at Morpeth, on the North-Eastern Railway, which demonstrated, the former the advantage of a continuous brake complying with this condition and the latter the want of such a brake. Both accidents were the result of a defective condition of the permanent way; and both trains were Scotch express trains. At Heeley the train was travelling at a speed of sixty miles an hour, when, in consequence of the road giving way under the engine, some of the carriages suddenly left the rails; and the first thing that attracted the attention of the head guard, riding in the hind-van, was the automatic action of his brake. The brake became acquainted with the damage before the man knew anything about it, and by its prompt action, converted what would otherwise have been a terrible destruction of vehicles, with considerable loss of life, into an accident accompanied by comparatively little damage to the rolling stock, or injury to the passengers. At Morpeth, on the other hand, where the train was travelling at far less speed, about twenty-five miles an hour, three carriages were so utterly destroyed as to be undistinguishable; the wheels of one of them, together with the remains of a passenger, were taken out afterwards from the tank of the tender into which they had been driven, and five passengers lost their lives. Without multiplying individual instances, it is sufficient to state that hardly any accident can occur of a serious character, with separation of the couplings, on the engine or any part of a train leaving the rails, from failures in the permanent way or rolling stock, or from obstructions, or at points, or crossings, in which it is not an all-important advantage to be provided with a brake which will thus at once act for itself irrespective of engines, vans, or other vehicles, and without waiting for the servants of the company to apply it at a time when they may be unable to do so. This desideratum will be the better understood when it is remembered that the destruction to the vehicles, and the loss of life to the passengers on such occasions, is commonly caused by the hinder carriages running forward with accumulating momentum upon the front carriages, and that this result is avoided when, the brakes on each vehicle being instantly self-applied, the momentum of each vehicle is at once checked, and such fatal results are thus avoided.

As a further condition of automatic action, the brake-blocks should fly on, and not off. They should, in other words, be applied to and not released from the wheels in the event of any failure of the apparatus. This condition will at once commend itself to those who urge, with truth, that the more generally continuous brakes are employed the more certainly engine-drivers will get into the habit of running smartly up to signals, into stations, and towards buffer-stops or other "dead ends."

There can be no doubt that this will be the natural tendency, and it must be expected and provided for. Men will never be otherwise than fallible, machinery will never be quite perfect. We weight our signals so that if the wire breaks they fly to danger, and we thus reduce in all ordinary cases what might be a risk of accident to a possible risk of delay. Similarly, it is essential, in employing continuous brakes, to provide that although a train may, on any defects occurring in any of their parts, be stopped prematurely, yet shall the driver not be carried accidentally too far without the means of pulling up. Otherwise, that which is intended as a means of safety, might be converted into a source of danger. The argument is sometimes put forward that, however good continuous brakes may be for service elsewhere, they ought not to be used in running into terminal stations. But a few words of actual experience will soon dispel this fallacy. When collisions occur in this way, from trains entering a station at too high a speed, the engine-driver commonly accuses the guard, and the guard the engine-driver. The train is perhaps a little heavier, or the rails more slippery, or there is less proportionate brake power than usual. But if the engine-driver has control of brakes over his whole train, then he has no occasion to rely on the guard or guards, the responsibility rests with him alone, and he is without excuse if he causes an accident. The most likely mode of producing such collisions is by distributing the brake power between two or three men in different parts of a train, without good means of acting together; and the best mode of avoiding such collisions is to place the responsibility and control both together in the hands of the engine-driver. No excuse remains in such a case for an engine-driver, when he is provided with ample brake power, which he can apply at pleasure, wholly or partially, of which he would not on ordinary occasions employ the full force, of which he would retain a reserve for every case of emergency, and which, if anything should happen to go wrong, would only by automatic action stop him sooner than he expected.

The most remarkable instance showing the necessity for compliance with this condition is the accident that occurred on the 11th November, last year, on the Jersey Central Railroad. A passenger train running to Communipaw Ferry, which ought to have been pulled up at the platform, dashed through the depôt almost with undiminished speed, carried away part of the goods office, crossed the ferry pier, and fell into the river. The engine driver trusted to his vacuum brake, which was not automatic, but his apparatus failed him at the critical moment. If his brake had been automatic, and thus self-applying on the failure of any of its parts, the engine-driver would have been previously warned, and the accident would not have occurred.

Having reference, then, to the approach of trains to terminal stations, junctions, level crossings, open bridges, buffer steps, and to all cases in which an accident might be caused by a train over-running a particular spot, all of which is comprised in ordinary railway working, the truth of the matter may be correctly stated by asserting that it is not safe to employ any continuous brake which is not automatic in the sense of flying on, or applying itself, when failure occurs in any of its parts; and, further, that a continuous brake which does comply with this condition of automatic action must afford a higher degree of safety than the existing arrangement of mechanical brakes distributed through different parts of a train, and is the only proper and suitable apparatus to employ.

Another advantage, in practical working, of a continuous brake which is self-applying, and requires to be taken off by the exertion of the force employed, that of proving itself to be in good order when the train starts, is not less important. Under other conditions a train may be started, with the brake apparatus not coupled up, or with its parts out of order, unknown to the driver, when he starts on a journey; and he may only discover that his brake is defective when he finds it failing to act, as it becomes necessary for him to bring his train to a stand. But when he is obliged, by the application of the brake force, to relieve the wheels of the blocks before it is possible for him to start, then there remains no risk—either from neglect of servants, or defect of machinery—of his leaving a terminal or other station with his brakes not in working order. This is, in fact, a condition of simplicity in working, true in principle, and of great advantage in daily practice.

The next important condition is promptness of action or application with full force of the blocks to the wheels, within say, one second, on a train of ten carriages. The necessity for this requirement will be at once realised when it is remembered that in one second a train travelling at 60 miles an hour passes over 88 ft.; at 45 miles an hour, 66 ft.; and at 30 miles an hour, 44 ft. A train travels, that is to say, 100 yards—at 60 miles an hour, in 3·4 seconds,—at 45 miles an hour in 4·6 seconds,—and at 30 miles an hour in 6·8 seconds. When an accident occurs in which a carriage leaves the rails from failure in any portion of a train, it may be of great, and even of vital importance, immediately to reduce the momentum of every part of it; and every extra second expended before this action is commenced may be a question of life and death. At Morpeth the engine fell over on its side 84 yards from the point at which, and say 10 seconds after, it first left the rails. This was an extreme case, but if, on the first separation of a coupling, say six seconds after the engine left the rails, every carriage had instantaneously and automatically applied its own brake, then, undoubtedly, the hinder carriages would, so far, have had their momentum checked during the four following seconds, and much of the terrible destruction which occurred by the hinder carriages running forward unimpeded upon the tender and some of the leading carriages, would have been avoided, and no lives would have been lost. In cases somewhat less sudden, and when an engine-driver finds an obstruction 100 to 200 yards in front of him, the instantaneous application of his brake will either prevent the collision or materially reduce the amount of damage, will save the passengers from injury, and will avert all risk from the subsequent rebound of the buffers—which is sometimes the cause of the worst damage—even if a collision ensue.

In such a case, for instance, as the recent collision at Saltney, on the Great Western Railway, where the engine-driver of a passenger train was warned by an engine-driver travelling in the opposite direction of an obstruction in his way, in the dark, 328 yards from him, caused by some waggons having, in shunting, been thrown from a siding, the passenger train might, by the instantaneous action of a good continuous brake, have been stopped short of the obstruction. And at Skipton, when thirty passengers were killed, the train, travelling at, say 40 miles an hour, might, apparently, by the instantaneous application of continuous brakes, have been brought to rest without any serious injury.

Another important condition of a continuous brake is "simplicity," and on this head I must be allowed to refer to my paper read in this room on 20th May, 1874. I then endeavoured to explain, with reference to the accusations of certain eminent railway gentlemen, as to the complicated arrangements which were, by the action of the Board of Trade, being forced upon railway companies, what simplicity as opposed to confusion in railway working, really meant; and that simplicity in construction, and simplicity in working, were, in many cases, distinct, and widely different from one another; complication in construction being frequently, or always more or less necessary to obtain simplicity in working. I then pointed out that simplicity in working was not obtained, "where in long heavy trains timed to travel at high speed, engine-drivers had not sufficient brake-power to enable them to bring their trains to a stand within reasonable distances, when they could not depend upon the guards hearing their brake-whistle, and when they had only a limited portion of retarding power under their own control," nor, "when they found it difficult to maintain their time-table speed, and at the same time approach each and every signal in the course of their journeys with the requisite amount of caution, according to the severity of the gradients, the slipperiness of the rails, the proportion of brake-power, and the positions and view afforded by such signals." I may now add that simplicity as regards the application of railway brakes is not obtained by the system now more commonly employed of brake-handles to be turned by different men in different parts of a train; but is obtained when, by more complicated construction, an engine-driver is able easily in an instant to apply ample brake power at pleasure with more or less force to every wheel of his train; is obtained when, every time an engine-driver starts, or attempts to start, his train, the brake itself informs him if it is out of order; and is still more obtained when, on the occasion of an accident and the separation of a coupling, the brakes will unfailingly apply themselves on every wheel of the train without the action of the engine-driver or guards, and before even they have time to realise the necessity for it. This is true simplicity in such a case; and that system of continuous brakes which best accomplishes such results in the shortest space of time is, so far, preferable to all others. As an instance of the want of simplicity of the present system, may be quoted the case of a recent accident at Derby. A night mail train which ought, on arriving at Derby, to have been stopped at the ticket platform, on the west of the station, ran past that platform, and came into violent collision with some carriages beyond it. The fireman, who was not well acquainted with the line or the station, took off his brake in the dark to allow the train to run forward on seeing a signal lowered, just at the moment when he ought to have screwed his brake on more tightly; and the engine driver only discovered the mistake which the fireman had committed when it was too late to correct it. I mention this case to show how desirable it is, not merely that the brakes should not be distributed between the fireman and guards in different parts of the train, but, further, that the engine-driver should, in the simplest form, be able himself to apply and release it, without the intervention of the fireman; and the engine-driver should be able to do so, without the exertion necessarily bestowed in turning the ordinary screw-brake on and off. As long as this common mechanical brake is employed, the engine-driver cannot be expected himself to work it; and yet this is the brake, which, it is fair to say, is still, by reason of its apparent simplicity, in favour with some of the most eminent authorities of the railway world.

The conditions of cost, maintenance, and efficiency cannot, with advantage, be separately considered. Any railway company which adopts a brake system not fulfilling the necessary requirements will undoubtedly be compelled, sooner or later, to change its brake apparatus; will thus ultimately incur much extra expense, and will be deprived, in the meantime, of the advantages obtained by the use of the best brake. There cannot be very much difference in first cost between different systems, if the same conditions be fulfilled, and if the same materials are employed. Durability and cheapness of maintenance must be, and efficiency is, undoubtedly, of greater importance than comparatively slight differences in first cost. Rubber sacks and rubber reservoirs, as used in some systems of continuous brakes, may be somewhat cheaper at first, but cannot be maintained as cheaply as iron cylinders and iron reservoirs. They must be less reliable, and must at times be more apt to fail, as they get old, when they are urgently wanted to act. The constant maintenance of materials of this description—which cannot properly be allowed to work till they burst or fail, but must be renewed at stated intervals—under every vehicle used with passenger trains on a railway would certainly prove, in a series of years, to be a troublesome matter. It is a novel idea in railway locomotive or carriage building to contemplate the use of such materials for permanent work, and for objects of such importance. But, whatever the materials or the

form of brakes, they should, at all events, be adapted and adopted for ordinary use, daily, hourly, and on the occasion of every stoppage made by a train. To keep one set of brakes for emergencies, and another set for ordinary use, as on the railway of one great railway company, is introducing a most objectionable principle. The tendency in the course of working such an arrangement from year to year would be, according to all precedent and all experience, for tests to be neglected, and for the emergency-brake to fall more or less into disuse. Apparatus of all descriptions on railways which is not constantly employed for useful purposes fails to receive that attention which is necessarily bestowed on other apparatus on which practical working constantly depends. Sooner or later, the time would surely arrive when the emergency-brake, suddenly required for a serious contingency, would fail to act; and then, if loss of life were the result, the laments would be bitter and unavailing. It may be safely asserted that there is scarcely any piece or form of construction or machinery on any railway, or anywhere else, from a hose-pipe to a house, from a distant signal to a locomotive engine, that is maintained from year's end to year's end in proper adjustment and condition, unless it be required for practical use; and, independently of the disadvantage as regards the servants, who may be required to work one set of brakes at one time and another set of brakes at another time, and may not, when an emergency arises, be able readily to make up their minds which handle to fly to, or which lever to operate upon, the system of employing only occasionally and for purposes of test, a brake specially provided for cases of extreme emergency, when perfection of adjustment and working is much required, when every second is vital, when luggage may be found in the way, is one which can only be looked upon as almost courting failure and disaster. As bearing upon the opposite principle, of relying continually upon the brake which would also be used in cases of emergency, and of providing an indication, constantly before the eyes of the servants of the company, of its condition and working, it would probably be wise in the case of pressure brakes to affix an indicator on every engine and on every brake van, by means of which they may see at a glance the condition of their brake power, and of its connections.

I have purposely avoided in this paper a multiplicity of details which it is unnecessary here to discuss, and which would only serve to divert attention from the main points: but without pretending to a complete treatment of this much varied question, I have, I believe, referred to the principal conditions which it is necessary for us to consider in deciding which system is the best for general adoption as a continuous brake for railway trains. These conditions are all practical and feasible, and may thus be summed up; (1) Simple and easy control, especially by engine-drivers, but also by guards of trains. (2) Automatic action in the case of an accident, or of a division of a train, without any interference from engine-driver or guards, so that the brake blocks may, on the separation of the couplings between any two carriages, be self-applied on every wheel. (3) The brake to fly on, and not off, so that the blocks may be applied to and not released from the wheels, on failure of any of the parts; and the train cannot be started unless the couplings are complete and the whole apparatus is in working order. (4) Instantaneous application—say to full force within one second of time—when operated by engine-driver or guard, or when self-applied. (5) Simplicity of working. (6) Moderate cost, as compared with efficient durability of parts, and easy maintenance. (7) Constant employment in the conduct of traffic, and not merely employment for testing, and in cases of emergency. (8) The engine-drivers and guards to be provided with indicators, showing at a glance the condition of the brake-power, and the continuity of the connections.

Keeping these cardinal points in view, it cannot be difficult, with an unprejudiced mind, to come to a conclusion as to the relative claims of rival inventors. I have mentioned no names, and I express no opinion as to which of the various systems advocated is best adapted for the ends to be accomplished. I invite all who are interested in this subject to take this opportunity of coming forward to state their own views, as to the conditions which should be fulfilled, the best means of complying with them, and the experience which has up to the present time been obtained; and I hope there may be a full and fair discussion commensurate with the importance of the subject. The only other means available to assist in leading to a decision, if doubt should still exist, are further trials; and on this point I would venture to suggest, in conclusion, that any fresh experiments should be publicly conducted on parallel lines, before impartial judges. In this way convincing results would best be obtained. The errors, and uncertainty and discrepancies, real or suspected, incidental to isolated trials by different people in different parts of the country, would be avoided. Similar and rival trains, running side by side, at the same speed, on rails in the same condition, and on the same gradients and curves, might be made to afford exact and obvious means of comparison, not only as to the respective powers of the brakes under trial, but also as to rapidity of application, automatic or otherwise, when worked by engine-drivers or guards, and at different periods of the stoppage. The time has come for decisive action, and the public interests at stake are sufficiently large to warrant a few days expended in experiments of this description, and it would probably be impossible otherwise to arrive at the much-to-be-desired consummation of unanimity amongst the railway companies.

THE NEW IMPERIAL GERMAN PATENT LAW.

A NEW Imperial Patent Law applying to the whole of the German empire has just been sanctioned by the Reichstag, and will come into operation on July 1st, when the separate patent arrangements of each kingdom and state will come to an end. Under the new law a patent is to last for fifteen years, and the direct payment to the Government, exclusive of payments to agents for plans, specifications, &c., amounts to over £260. At first sight this seems to be a heavy tax, but it really is not so, being rendered less burdensome by being spread over the whole term of fifteen years. An English patentee, who patents a doubtful invention, stakes £50 on the first year's results, whereas, under the new German law, the first year's payment is only £2, 10s.; the second, the same sum; the third, £5; the fourth, £7 10s.; and so on to the end of the term by equal yearly increments of £2 10s. The weight of the tax consequently falls most heavily on the most successful invention. Another good point in the law is that three months grace is given from the yearly payment, a concession of no slight value, for we have known of several valuable English patents which have been lost through mere inadvertence in not making the necessary payments at the time fixed. Pharmaceutical compound medicines, food preparations and chemical products themselves, cannot be patented, although the processes for making them can. German citizens cannot take out patents for foreign inventions, except by consent of their patentees; and foreigners cannot take out a German patent except through a German citizen. Any one who can prove that he has used an invention before the patent has been taken out can continue to use it in spite of the patentee, who still has his remedy against any third person who may infringe his patent after it has been taken out. Applications for patents will be submitted to an Imperial Commission, aided by experts, who will reject or accept them as they think fit. Two appeals against their decision are allowed—one to a Special Commissioner, and from him to the Imperial Court at Leipzig. If, after three years, the inventor does not carry out his invention, or, if he refuses to grant licences to others offering a fair royalty, his right lapses. These two restrictions seems to us to be harsh and indefensible, and seem likely to give rise to great discontent in numerous instances. The latter claim seems especially hard. If applied to commercial product, the harshness of it is at once apparent. How would a cloth merchant, for instance, like to be compelled to sell his goods at cost price to any one demanding them on payment of a "fair royalty." Patents in any of the German states can be converted into Imperial Patents for the time they have to run on payment of a small fee.

BRICK-MAKING.

ME who would write the story of brick-making would have a task of which he had no idea when he promised. Ages elapsed before the tradition of the Jewish people in Egypt, by which we have the intimation concerning the proper and unsuitable materials, was published to the world. In those ages good bricks were made; indeed, it is a rebuke to modern society and an objection to modern science that men do not want honest bricks, and that science—the immaculate—should be bound to provide an imitation that shall designedly deceive.

Brick-making, to be profitable, must consult and adopt the counsel of engineers. Locality, fuel, and transport are important adjuncts in a calculation that involves a spending of three or ten thousand pounds in subjecting or absorbing an existent and well ordered population. The defects of existing machinery for making bricks are known to all the artisan world.

What with the insane propensity of working people for shortening production and augmenting *for a time* the daily wage, does it not show the pressure of competition with all its commissions and relative obligations, and is not that the vindication of machinery?

So many failures in brick-making machines having been made, they are looked upon with more distrust than almost any other kind of machinery; the principal defects being want of strength, durability, and suitability, resulting in breakages, continual repairs, and constant care in preparing the clay so that the machine can use it, rather than studying the quality of the brick; thereby the cost is raised to near handmade prices. The machine of Mr. Brownhills is made with a very large margin of strength, and, as it were, free of cost; for, having increased the dimensions of the working parts, it gives another desirable condition—durability, and the other very important requirement—suitability; so that it can work up any kind of brick earth in any condition—rough from the earth—ground—disintegrated—wet—dry, or semi-dry. It is constructed to combine these conditions, and any kind of material in any condition that can make bricks can be used, without previously preparing, wetting, or drying.

Stones and metallic substances will not injure it; but the practical brick-maker should select and prepare the materials having reference to the quality of the bricks he desires to make, as where there are various layers of earth of different characters, or containing stones, the materials should be ground and well mixed. It is not necessary that the clay should be mixed with water to the consistency used for hand-made bricks in order to get good bricks. The clay must be well ground, for a small stone or piece of dry clay would cause the brick to crack from unequal contraction.

The plasticity of clay does not depend upon water mechanically added, the basis of clay being alumina and silica; alumina giving plasticity, and silica preserving the shape during burning. Alumina does not lose its chemical equivalent of water, upon which plasticity depends, until the temperature is raised about 1,000 degrees Fahrenheit. Therefore, it is obvious that clay made into a brick, nearly dry, is the best condition we can possibly get, and if a sufficient pressure is given, according to the nature of the material, a good sound brick is the result, besides an immense saving in capital, labour, and fuel.

We illustrate on p. 115 a new brick machine, being introduced by the maker and patentee, Mr. R. W. Brownhill, of Birchills Foundry, Walsall. B is a strong cast-iron frame, with moulding box S cast on it. Upon this frame the whole of the machine is fixed. C C are two square slide boxes to guide the pistons *e e*, which form two sides of the brick. The two pistons, which slide in the boxes C C, are fitted with strong friction rollers, which revolve and follow the two cams on the main shafts. The pulleys C *e*, and the chains and weights G G, are to keep the pistons with friction rollers to work close to the cams cast upon the main shafts during their irregular motion. The hammer to drive the clay into the mould S works on the slides A A, connected at the top by the cap N, falls during every revolution, and supplies and consolidates the clay through the hopper E into the moulding box S, and between the piston pallets *e e*. The hammer is operated upon by the helve Q T, which works upon a rocker R, which turns upon a gudgeon *g*, at the bottom end of the helve. T is fitted with a friction roller, to work upon the spiral U, which spiral is connected to the large spur wheel, and by this means the hammer is raised, and then dropped with the full force of its own weight. There is a radius rod which works upon the centres Z Y on the helve and standard, on the back side, which cannot be seen on the drawing, to guide the hammer. The large hopper W is for the purpose of holding a quantity of material for the screw, and is deliverod into the hopper proper by the screw, which is driven by the cone pulleys *f f*, by a pair of bevel wheels, which are not upon the drawing, but are situated at the back of the hopper W. These cone pulleys are driven by the shaft and pinion working into the large wheel. The pair of bevel wheels X are worked from the same shaft, for the purpose of keeping the feeding screw clear. The pallets *e e* deliver the bricks upon the band P. This band is worked by a small band pulley situated on the other side of the machine from that shown on the drawing, and is worked by a pair of bevel wheels and shaft, actuated by the ratchet wheel S and pair of spur wheels, which are put in motion by the rod *r*, worked by the crank plate *q*. The pulley which drives the band P is lifted at the exact moment when each brick comes out of the mould, to take it off the pallets. This is accomplished by a lever, moved by a cam fixed on one of the large shafts at the back of the machine. The pallets *e e* are supplied with steam to make them hot to prevent the bricks from sticking to them. Clay is fed into the hopper W either by hand from the heap or from the grinding apparatus. The screw revolving at the bottom of this hopper carries an adjustable quantity of clay into the hopper proper E. Under this hopper the distance is regulated between the pallets for a regular quantity of feed, and in reality becomes the mould. Just at the moment the pistons are in this position the hammer falls, and forces the material into the mould. The motion of the cams causes one piston to retire while the other advances, and presses the brick. The retiring piston then entirely leaves the mould, and the advancing piston forces the brick out of the mould, to be taken away by the band before described, and thus completes one brick. The machine is adjustable in all its motions.

The machine works about twenty-two tons, and will, we are informed, make from 30,000 to 40,000 bricks per week at a cost of 1s. per thousand for attendance on the machine. It is stated that excellent bricks are turned out by this machine from raw clay entering unprepared. One has been worked regularly for the last nine months.

BRONZE.

THE Society of Arts has rendered excellent service in affording an opportunity for those who have something new to say concerning the use of compounds. It has been the means of building up many arts by encouraging the student who has acquired some knowledge to still further employ his powers, and evolve a higher development, not only of his art, but of his own nature.

Bronze has always contained secrets. The admixture of its elements varies indefinitely, and we have not yet any prospect of seeing the end of the process. There are manufacturers now whose secret is not revealed; and, no doubt, there have been many whose secret never has been revealed, and will have to be rediscovered if ever mankind obtains the knowledge that is lost.

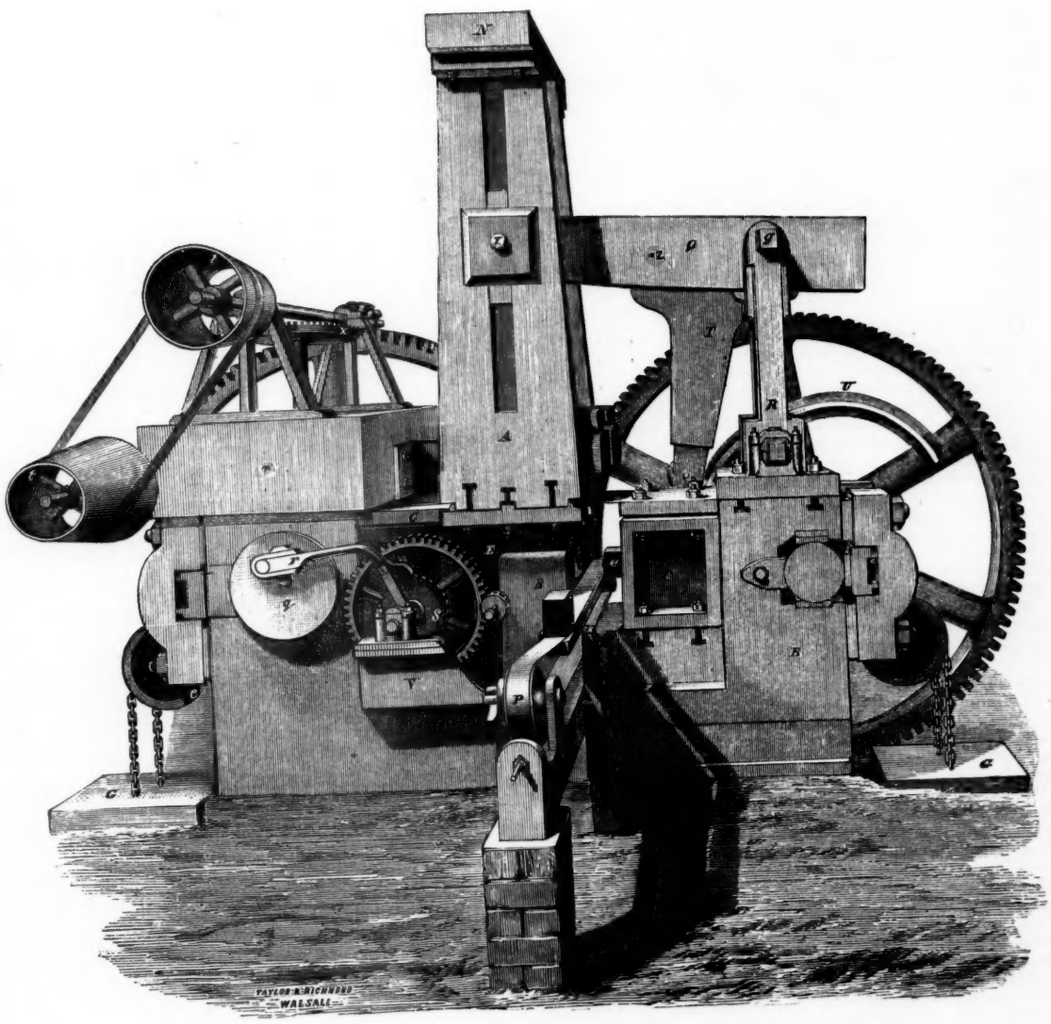
Its antiquity antedates all other alloys. No matter where you dig, or what may be turned up that has any recognisable date, bronze is there. Iron, copper, silver, gold, and tin are always known, but bronze is ever the imperishable token of ages long past, and it endures the wear of ages far beyond the very metals of which it is composed. There are a score of kinds known to the ancients; and it would be strange if, in an age when science and art can do almost anything in the way of imitation, that score is not multiplied indefinitely. The old people had their ancient bronze nails, flexible, made of copper and tin, in the proportion of 20 to 1; and thin soft bronze, 9 to 1; and thin medium, 8 to 1. They made it into weapons and tools; they also struck from it medals, using tin to give them brightness. We use it in the way of gun-metal, soft and yielding; we use it for mathematical instruments, and for cogged wheels; we employ it in what we call brass ordnance; and for another, music bells. The Chinese made of it their gongs and cymbals, and other people know its service in house bells, church bells, and in every form wherein oxidation is an evil to be avoided.

As a subject especially interesting in our time, the Council of the Society of Arts have rendered a good yeoman's service in giving permission to Mr. Alexander Dick to deliver a discourse on Phosphor-Bronze and its applications. This is scientific, and therefore accurate. The experiments it recites are worthy of especial notice. The whole treatment of bronze has always been, to a great extent, a chapter of accidents, and we must be thankful for any aid that shall give us a hope to understand chemically what is done and how it is done. It is but very recently that any light has been thrown on the nature and cause of the difficulties of the bronze-founder in getting properly tested copper and tin, and then in obtaining sound and reliable castings. We begin to know how to avoid them or to apply a remedy.

In the year 1868, Messrs. Montefiore & Künzel, of Liége, in Belgium, engaged in a series of very exhaustive experiments with bronze and bronze castings. These gentlemen observed that the tin in bronze continually decreases by oxidation during the process of smelting. They found that the oxide of tin partly goes into the slag and partly is dissolved in the molten metal.

	Tin.	Copper.
Bronze, originally composed of . .	10·10	+ 89·90
Contained after the first melting .	9·82	+ 90·18
" " second " .	9·40	+ 90·60
" " third " .	9·16	+ 90·84
" " fourth " .	8·52	+ 91·48

The operators found great difficulty in determining analytically the proportions of the oxides, whether in combination with the


TAYLOR & RICHARDS
WALSALL

tin or copper, or whether only mixed up in the metal; they found that "poling," a process by which the molten metal is stirred up without a wooden stick, will eliminate the oxide combined with copper, but has no influence on the oxide of tin; experiments by passing hydrogen over heated bronze filings proved equally ineffectual; the oxide combined with the copper was converted into water, and weighed as such, but the oxide of tin remained like in the "poling" process. It was in consequence of this difficulty that Dr. Künzel, for the first time, introduced phosphorus into the molten bronze; this had the desired effect, and the metal, which at first had a dull and covered appearance, all of a sudden became bright and of metallic surface. Thus, by introducing a small proportion of phosphorus, or phosphuret of tin or copper, of previously ascertained composition, it was found that the total amount of oxygen contained in the molten metal could be ascertained analytically with perfect certainty. The absolute and elastic resistance of old bronze, that is, bronze containing oxides, is much smaller than that of bronze with new metal; and, as will be seen by the following experiment, "poling" will improve old bronze, whilst phosphorus greatly improves bronze "poled." Shavings of old bronze were melted and a bar thereof cast at 1595 deg. C., the remaining liquid bronze was stirred with a wooden stick—"poled"—and a second bar cast at 1668 deg. C. The then remaining metal was deoxidised with phosphorus and a bar cast at 1614 deg. C. The three castings were thus made out of the same crucible and cast in the same manner in three moulds. The results were :—

	Resistance. absolute lbs. per sq. in.	Resistance. elastic lbs. per sq. in.	Lengthening until rupture. Per cent.
Old bronze	22,982	17,020	2·0
„ poled	24,922	17,709	2·8
„ deoxidised with phosphorus	33,916	19,300	6·8

Thus, by the entire reduction—elimination of oxide—the old bronze has tripled its tenacity and considerably augmented its absolute resistance.

Having so far succeeded in eliminating the oxides from the bronze, the inventors showed that by the further addition of a small percentage of phosphorus to the bronze alloy the qualities of the latter became more and more changed, the grain or fracture became finer, the colour brighter, the elasticity and resistance to strain and compression considerably increased, and when melted it attained great fluidity. Similarly, as minute quantities of carbon alter the physical properties of iron and convert the latter into steel, so a minute quantity of phosphorus changes those of bronze and converts the same into phosphor-bronze. It may thus be said in a certain sense that what steel is to iron, phosphor-bronze is to ordinary bronze.

Messrs. Montefiore and Künzel next experimented with alloys of copper and nickel, and with manganese—binary alloys—also with—ternary—bronzes of copper, tin, and manganese, with copper, tin, and nickel, as well as with iron alloyed with copper and tin. The manganese alloys they concluded to be entirely useless, as also those of nickel and of iron. They obtained great tensile strength and hardness with some of these compositions, but their ready oxidability at high temperatures made the qualities of the castings uncertain and impracticable.

Sodium eliminated the oxides contained in the molten bronze, but the slightest surplus of it produced an alloy which could not resist the atmospheric influences, and oxidised with great rapidity. A minute addition of zinc to ordinary bronze augments the resistance to rupture by reducing involved oxides, but it softens the alloy and causes it to lose its elasticity. Phosphorus was therefore found to be the only ingredient which will improve bronze by giving reliable results. The action of phosphorus is twofold—(1) it eliminates the oxides as stated above, and (2) it makes the tin capable of adopting a crystalline structure—and, as two crystalline metals form a much more homogeneous alloy than two metals, of which one is not crystalline, phosphor bronze must necessarily be more homogeneous than ordinary bronze. Homogeneity and absence of oxygen increase the elasticity and absolute resistance of the alloy. Another great advantage of phosphor-bronze is that its hardness can be regulated by varying the proportion of phosphorus, which, in ordinary bronze, is done by increasing the proportion of tin, whereby the danger of segregation in the casting is greatly augmented. Ordinary bronze, after one or two smeltings, becomes thick-flowing, and putty like, whilst phosphor bronze remains perfectly liquid until the moment it sets—solidifies; if, therefore, it is cast just before the "setting" takes place, no segregation is possible. Combinations of phosphorus with copper, with tin, or with other metals, have long been known by chemists, but Dr. Künzel was the first to employ the same for the purposes above stated. A number of phosphor-bronze alloys are now manufactured, varying in composition to suit the objects for which they are intended. The scope of their applications is of course very great. The harder alloys are used for casting bells, tools for gunpowder mills, &c.; other somewhat softer alloys are used for engineering purposes, and the still softer for rolling, drawing, and embossing, &c.

The following tables will show the results of tests made by Mr. Kirkaldy, of Southwark Street, with various phosphor-bronze alloys :—

Cast metal.	Diminution of section before rupture.	Resistance in lbs. per square inch. Elastic.	Absolute.
	Per cent.	lb.	lb.
Pure copper	3·30	4·4000	6·975
Ordinary gun-metal, containing nine parts copper, one part tin	3·60	12·800	16·650
Phosphor-bronze	8·40	23·800	52·625
„ „	1·50	24·700	46·100
„ „	33·40	16·100	44·448

Drawn Metal.	Pulling stress per sq. in. Wire as drawn.	Annealed.	Twists in 5 in. Wire as drawn.	Annealed.	Ultimate extension.
	lb.	lb.	lb.	lb.	Per ct.
Various alloys. Phosphor-Bronze	102·759	49·351	6·7	89	37·5
„ „	120·957	47·787	22·3	52	34·1
„ „	120·950	52·381	13·0	124	42·4
„ „	139·141	54·111	17·3	53	44·9
„ „	159·515	58·853	13·3	66	46·6
„ „	151·119	64·569	15·8	60	42.8
Copper	63·122	37·002	86·7	96	34·1
Steel	120·976	74·637	22·4	79	10.9
Iron, galvanised best charcoal E	65·834	46·160	48·0	87	28.0

A series of interesting experiments with phosphor-bronze were made in Berlin by the Royal Academy of Industry, in order to ascertain the qualities and capacities of the metal whilst under heavy strain, and its resistance to often repeated strains. The first bar of phosphor-bronze was tried under a constant strain of 10 tons per square inch, and resisted 408,230 pulls; a bar of ordinary bronze broke even before the strain of 10 tons per square inch had been attained. A second bar of phosphor-bronze was tried under a strain of 12½ tons per square inch, and withstood 147,850 pulls, and a third bar, under 7½ tons strain, broke only after 3,100,000 pulls. On the bending machine, phosphor-bronze, whilst under 9 tons strain per square inch, remained unbroken after 4,000,000 bends, whilst ordinary bronze broke after 150,000 bends. Major Majendie tested phosphor-bronze as to its liability to emit sparks when subject to friction, and attained very satisfactory results. The experiments were carried out at the Royal gunpowder works at Waltham Abbey. A grindstone of 9 in. diameter was made to revolve very rapidly, so that any point on the grinding face would describe a distance of 2000 feet per minute; the metal was then pressed against the revolving stone, and the results proved that the harder descriptions of phosphor-bronze emit sparks less readily than the softer samples, and much less readily than ordinary gun-metal or copper.

For frictional purposes the Phosphor Bronze Company, in London, produces a special alloy, by fusing phosphor-bronze in certain proportions, together with another soft alloy of different degree of fusibility, so as to produce by cooling the given alloys. The shell is then formed of a very tough and hard phosphor-bronze, and the interior of aforesaid soft alloy. The bearing surface may then be considered to consist of a large number of small bearings of soft metal, enclosed in castings of metal almost as hard as the arbor itself. The microscope reveals this disposition very plainly, and if one of these bearings be carefully submitted to heat, so as to cause the soft fusible metal to run off, the rest will remain in the form of a spongy

mass. Bearings, slides, eccentrics, &c., of this peculiar alloy are now very largely in use, and the practical results show that it wears more than five times as long as gun-metal.

Phosphor-bronze is readily rolled or beaten out into sheets. In Russia it has been used as a material for cartridge sheathing, and specimens have stood 120 trials without tearing. Sheets of the alloy stand the action of sea water much better than copper. In a comparative experiment tried at Blankenbergh, lasting over a period of six months, between the best English copper and phosphor-bronze, the following results were arrived at :—

Thickness of the sheets = 0·236 in.	Weight before immersion	Weight after immersion	Loss of weight.	
	lb.	lb.	lb.	Per cent.
Sheet of copper	74·4	72·2	2·2	3·015
„ „	88·9	86·2	2·7	3·100
Sheet of phosphor-bronze .	69·5	68·75	0·75	1·123
„ „ „ . .	114·3	112·97	1·33	1·195

The loss in weight, therefore, due to the oxidising action of seawater during the six months' trial, averaged for the English copper 3·058 per cent., while that of the phosphor-bronze was but 1·158 per cent., or about one-third. Several Governments have experimented on the use of the alloy for making cannons. Without any exception, the results showed a much greater resisting power over that possessed by ordinary bronze. The following instances of the results arrived at will be of general interest :—

In Belgium the ordinary bronze gun burst at the second shot, with a charge of 1 k. 250 gr. (2¾ lb.) of powder, and a cylindrical projectile weighing 8 k. 518 gr. (18¾ lb.) The phosphor-bronze gun supported this charge perfectly ; the normal charge was 500 gr. (1⅒th lb) of powder, and 3 k. (6¾ lb.) of projectile.

In France the ordinary bronze gun burst at the second shot, with a charge of 1 k. 500 gr. (3½ lb.) of powder, and 16 k. (35¼ lb.) of projectile, while the phosphor-bronze gun was fired five times with this charge, and burst at the second shot with 1 k. 705 gr. (3⅞lb.) of powder, and a projectile of 20 kil. (44 lb.), owing to the wedging of this in the barrel. The normal charge was 0 kil. 550 gr. (1¾ lb.) powder and a bomb of 4 kil. (8¾ lb.)

In Prussia it was shown in firing with the regulation charges, and diminishing at each fifty shots the exterior diameter of the chamber that the phosphor-bronze cannons only changed their dimensions when the thickness of the metal was below that of the dimensions of a cannon of the same calibre made of steel.

The Belgian Government has adopted the phosphor-bronze for small arms and for the harness buckles of all their cavalry.

In conclusion, I beg to draw attention to the specimens of phosphor-bronze exhibited here—they are separated into different groups, each group is headed by an ingot of the phosphor-bronze alloy used for the manufacture of the various articles belonging to that group.

THE OXIDIZATION OF IRON.

NOTHING in the whole range of modern mechanical and scientific knowledge and research can compare with the intense anxiety of engineers and capitalists about the surprising effects of rust. In London you cannot go through a huge iron and glass station without a risk of two feet incrustations dropping on your head ; and all about, where iron railings are, the same decay goes on. The oil-and-colour-man said if you used his hematite there could be no danger ; but his service is only six months reserve for death, and unfortunately the stuff is amenable to operations which by adulteration or by fraud destroy what was really possible.

None of us can vouch authoritatively for the excellence of remedies. They may fail ; they may be prescribed with the intention of failing : and it is a grief to all good men that such proceedings are enacted. Nevertheless, iron is too good a product to be friendless. Like all elements it has an enemy, but like all good things it has friends. The whole of modern machinery is a war ; it aims to subjugate natural forces to the service of man : and therefore we must not complain if in our attack and our conquest we get a repulse. It is the fate of war. Iron is a marvellous and multiform blessing. A chapter could be written thereupon. But iron gets rusty ; and rust is death. Professor Bartt tells us wonders that will make him immortal if they are substantiated or vindicated ; and we are only doing justice in saying that it does seem to be probable that every word of his lecture at the Society of Arts will be made good. The subject is one that as a matter of chemistry is of intense importance, and in commerce or capitalistic business almost vital. We therefore place Professor Bartt's lecture before our readers in its entirety, so far as this subject of oxidization is concerned : "While experimenting, two or three years ago, with my friend, Mr. Hugh Smith, on different methods for preventing incrustation and corroding of steam-boilers, I was led, through the failure of all the processes employed, to believe that, if it were possible to convert the surfaces of iron plates into the magnetic, or black oxide of iron, in such a manner that the particles of black oxide formed in the position of the original particles of iron could be rendered perfectly adherent to the iron surface, which does not become per-oxidised, and perfectly coherent with one another, the object would be effected. I do not intend to enter into the chemistry of the oxidation of iron to its full extent ; it would take too much time, and it would rather tend to confuse than to enlighten those who are not well up in their chemistry, and would raise questions which would bring on prematurely a collision with the views of some of my brother chemists, which collision, under suitable circumstances, at some future time, not very remote, I look forward to with considerable satisfaction, as it will be the means of solving many phenomena which have never yet been explained. A piece of dry iron, its surface being polished, may be exposed for any length of time to dry air without rusting, but it begins to rust at once as soon as the slightest moisture comes in contact with it. We have to consider only two oxides of iron : one containing 56 parts by weight of the metal to 16 parts of oxygen, and the other containing twice 56 parts of iron and three times 16 parts by weight of oxygen. We speak of these oxides as the protoxide and sesquioxide, or as ferrous and ferric oxide.

Immediately the protoxide is formed, it being more moist, it unites with oxygen and becomes gradually converted into the ferric oxide. Now, let us suppose a moist iron plate to come into contact with oxygen. It is clear that the protoxide will be first formed, and this rapidly becomes converted into the higher oxide. Now, suppose you take a solution of the salt of the higher oxide and put into it metallic iron, in time, the air being excluded, this higher salt will become converted into a salt of the lower oxide. Let us now see how this bears upon the rapid oxidation of iron in the presence of moisture. We have seen that when oxygen comes in contact with moisture the first oxide is formed and becomes rapidly oxidised into the higher one. But this higher oxide is in contact with metallic iron, which will reduce it to the lower oxide, thus becoming oxidised by the oxygen which it has taken up from the higher oxide. You will now see clearly how it is that iron rusts throughout its whole substance with such rapidity, for the oxide of iron serves as a carrier for atmospheric oxygen to the iron to almost any depth. There is another oxide of iron, called the black or magnetic oxide, containing 3 times 56 parts by weight of iron, and 4 times 16 parts by weight of oxygen. Some chemists consider this oxide to be a sort of mixture of the two others, and they call it ferroso-ferric oxide ; whether this be the case or not does not matter to us this evening. But it is a most important point for our consideration, that this oxide undergoes no change whatever in the presence of moisture and atmospheric oxygen. Nor does any temperature to which it can be exposed, in any of the ordinary uses to which iron is applied in the presence of moisture, either decompose it or produce its further oxidation. In every school where chemistry is taught, in the most elementary lecture on hydrogen, the pupils are told that if they pass steam over red-hot iron filings contained in an iron tube, they will be able to collect and burn hydrogen gas at the opposite end of the tube to where the steam enters. For a long time it was thought that the particles of black oxide formed by this decomposition of the steam were pulverulent, and could not be made to cohere into a solid mass. The result of a considerable number of experiments has been to prove that they can be made not only coherent amongst themselves, but adherent to the body, and that both these produce a proper formation of this black oxide on the surface of iron plates ; for, as I will show you later on, the oxidised surface of the iron resists for a long time, and more effectually, the rubbing with emery paper, than does the simple metallic iron itself, and that there is a very manifest difference between the ease with which a sharp rasp is able to cut away the surface of the iron, and the difficulty with which this black oxide is removed from the surface by that same instrument. The method which long experience has taught us is the best for carrying out this process for the protection of iron articles in common use, is to raise the temperature of those articles, in a suitable chamber, say to 500° F., and then pass the steam from a suitable generator into this chamber, keeping these articles for five, six, or seven hours, as the case may be, at that temperature in an

atmosphere of superheated steam. I will presently call your attention to the diagram of the furnace and muffle which I have employed in all our later experiments, and in which all the specimens before you, which will be alluded to in this paper, were prepared. Differences of temperature are employed where different objects are to be obtained. If it be wished to act upon surfaces of polished iron or steel, it is desirable to let the temperature remain at 500° F., until the operation is completed. Articles coated in this way will not resist the action of continued moisture such as has prevailed for the last two months, when exposed out of doors; but they will resist the action of any amount of moisture with which they may come in contact in a house or building; and the reason of this will be very obvious, because only a thin film of the iron on its surface is transformed into the black oxide. This I will explain more fully to you, when I call your attention to individual specimens. At a temperature of 1,200° F., and under an exposure to superheated steam for six or seven hours, the iron surface becomes so changed that it will stand the action of water for any length of time, even if that water be impregnated with the acid fumes of the laboratory. Before calling your attention to our failures and successes as they lie before you on the table, I will just allude to a few of the uses to which this process may be, as I consider, successfully applied—to water-mains, also to water-connecting pipes, as well as to the water-pipes used inside the house, which, in this case, would supplant their leaden predecessors. In this hall of hygiene, these words will, doubtless, sound as sweet music to the ears of many of those who have honoured me with their attendance this evening. The greatest objection to the use of iron pipes for the supply of water in houses hitherto has been this, that by rusting they caused the first quantities of water drawn off in the morning to be dirty and turbid; now this will be entirely prevented, if the pipes be first exposed to the treatment which I have just explained to you—of course gas-pipes could with advantage be similarly acted upon—and as the surface, when oxidised, is harder than the natural surface of the iron, the friction of large bodies of water through the pipes, and the friction necessarily employed in fixing them in their places, would be much better resisted than by the untreated iron itself. I cannot over-estimate the advantages which the employment of this process must confer on architects, who will be by it enabled to employ iron, whether wrought, or cast, much more largely, not only in the decoration, but in the construction of their buildings. Last summer, I was at a very large house in the country, where the entrance portico, some 20 feet high, was being painted and decorated, when one of the large plaster ornaments of the ceiling broke away from its holdings, and would have fallen to the ground except that it was caught by a workman. This ornament weighed not less than 25 lb., and if it had fallen from this height upon the workmen below, it must have killed them. The ornament had been there many years, and was fixed up in the best method possible, it being supported and secured by iron rods. On examination I found that these rods were rusted through completely to the very centre. I need not make any comment upon this, since I have been able to introduce you to iron treated in such a way that it will never rust. Of course if the process will answer for architectural ornaments, it will answer for statues, so that iron may be used instead of bronze, which will materially lessen the cost of casting statues, both in the material and in the expense of making the moulds. You well know that when a tinned saucepan is allowed to get dry on the fire and burns, as the servant calls it, that it is rendered useless until it is tinned again. Now, if such a saucepan be treated by the method I recommend, it may be allowed to get red-hot without suffering injury, for the protection on its surface is produced at a red heat. We have experimented on some screws, hinges, locks, keys, bolts, with complete success. It has been suggested to me that the iron nipples used in gas-lights would not corrode, and would, therefore, be more useful, if submitted to this action of superheated steam. Wherever iron is used, railings, street gas-posts, iron safes for keeping documents fire-proof and thief-proof, the framework of filters, tanks, cisterns for domestic and other uses, iron employed in the erection of temporary buildings—which, I flatter myself, if treated by this process, would become permanent buildings—all these, and many other applications of iron to the arts, would immensely gain by being submitted to this oxidising action. I think I need hardly take up your time by enumerating other applications for the preservation of iron, for it appears to me that they would be commensurate with most of the uses to which iron is applied, save and except those where friction—such as that to which rails and iron wheels are exposed—would necessarily wear away the coating, as they wear away the material itself. I am happy to see a namesake of mine here present this evening, who will tell you that he is carrying out a process for the manufacture of peat into charcoal by the action of superheated steam, and that he is enabled, by superheated steam alone, to raise the temperature of his chambers to a red heat, quite sufficient to effect his carbonising process. I will now call your attention to the specimens here before you, and to a description of the furnace which we employ, and I shall be most happy to explain, on being questioned, any parts of my process which may appear to be obscure, and to answer, if I can, any objections which you, gentlemen, in the interests of science, will feel it your duty to bring against it."

PUMPS.

THE progress of Mechanical Science has a striking exemplification in the contrast seen in the past and present state of the subject of hydraulics. Simple as simplicity itself at the beginning, it has probably the most extensive variety of application of any of the cardinal forces, commonly called elementary. We propose to restrict the notice of the subject at the present time to that of Machines for raising fluids.

The Jurors at the Great Exhibition of 1851 reported that, "Notwithstanding the great antiquity of the pump, and its extensive use, it is one of our worst machines, considered as a means of producing a given result with the smallest possible expenditure of power." The loss of power at that time in the construction of lifting and forcing pumps, amounted to 60 or 70 per cent. of the whole. So that of the work (in pounds, one foot high) done by the motive power to drive the pump, only 45 per cent. in the best and 18 per cent. in the worst was productive. Hydraulic Machines could yield in the water raised 75 per cent. of the work done to raise it; but the left and force pump could not yield more than between 35 and 45 per cent.

The pump thus condemned, became the favourite study of Mechanical Engineers, who resolved to do their utmost to make the pump superior to the machine. The causes of lost power were, first, The small size and ill construction of the valves; second, The wrong proportion of the section of the barrel to that of the section and force pipes; third, In the form of the section-pipe at the end where the water enters, and of the force-pipe, where the water is discharged; fourth, In the form of the connecting pipes to the barrel; fifth, In the proportion of the length of barrel to the depth from which water is raised. These were the recognised difficulties, and we shall endeavour to see how science has removed or minimized them, during the last twenty-five years.

The *forcing pump* (fig. 1) consists of a working barrel in which a tightly fitting piston works up and down. At the bottom of the barrel is a pipe leading to the well or pond and is furnished with a strainer at the bottom to keep out the stones. The hole or point of junction between the barrel and the pipe is closed by a valve. From the side of the barrel there passes upwards and outwards an ascending tube which is also closed by a valve opening outwards. This is the oldest and simplest form of

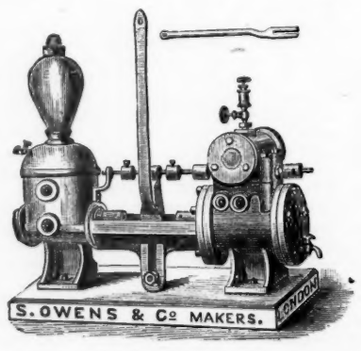


Fig. 1.

pump. When the piston is raised the water follows until the stroke ends and it cannot go back because of the valve at the side. Manifestly every thing depends upon the perfection of the valve part of the machinery, and in order to increase the bulk of water raised and the height to which it could be raised, many improvements have been adopted as to size and facing of valves, and the result is that double the former examples can now be effected

with ease. Valves are made larger and other materials employed in their formation. Leather is not the only resort. Metal, India rubber, and zinc are used with success by those who happen to know how to avail themselves of every discovery that may conduce to a desired end.

The sucking-pump or suction-pump (fig. 2.) is rather more complicated, having more valves. There, in addition to the valve closing the bottom of the barrel, there is a valve in the working piston which alternates in its action with the bottom valve. Thus, on raising the piston, the bottom valve opens and draws first air and then water from the pipe leading into the well. On lowering the piston the bottom valve shuts, and the piston valve opens, and allows the air or water to pass through the valve to

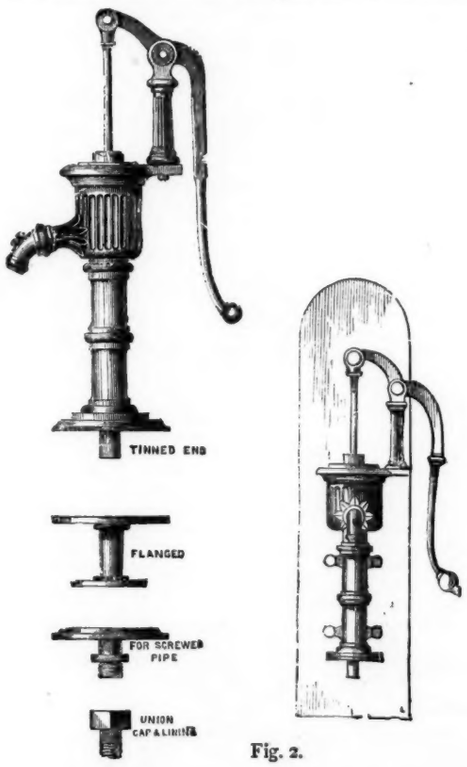


Fig. 2.

above the piston. The piston having arrived at the bottom of the barrel is again raised ; air from the pipe opens the lower valve and follows the piston, water supplies the place of the air drawn out of the pipe : this second portion of air is expelled by lowering the piston. Repeating these, the flow becomes continuous by the stream of water having driven out the air.

This variation of force was found to be very considerable, involving a loss of power on the one hand and an irregularity on the other, and it was evident that the ratios of the sections of the suction-pipe or force-pump must accord to the suction of the barrel. From inattention to this arose great loss of power. Again, the amount of the discharge of water by the force-pump was largely influenced by the form of the nozzle ; to that was added the discovery that the form of the extremity of the suction pipe by which the water enters, has an equal effect in facilitating its ingress. A similar remark applied to that extremity of each pipe by which it communicated with the barrel.

There was observed a loss of power due to the communication of an unnecessary velocity to the water raised. Any one who gives a succession of quick strokes to the piston of a common sucking pipe, allowing sufficient time between them for all the water which can enter the barrel to do so, will find in these old pumps the discharge per stroke to be considerably greater than when the piston is raised slowly. A certain amount of power, and no more, was required to be done on the piston in order to raise enough water from the well to fill the barrel. When more than that was done, the surplus manifested itself under the form of *vis visa* communicated to the water, by which, if space sufficed, more water was brought into the barrel than was due to the volume generated by the piston. Half this measured the surplus work. A shock ensued, which continually put the valves out of order, especially those made of metal. What was wanted was that the proportions of a pump worked by a given motive power should be such that the power to be expended at every stroke should just bring the raised water to rest at the end of each stroke. These proportions were ascertained without difficulty, but there were many difficulties intervened to delay their acceptance and application.

Although the piston is so familiar to us all, there is a want of recognition of the importance attached to its form and construction. In his celebrated book on " Mechanics," Dr. Robison puts the subject in a popular style. " The piston is a sort of truncated cone, generally made of wood not apt to split, such as elm or beech. The small end is cut off at the sides so as to form a sort of arch by which it is fastened to the iron rod or spear. The two ends of the conical part may be hooped up with brass. The cone has its larger end surrounded with a ring or band of strong leather, fastened with nails, or by a copper hoop, which is driven on at the smaller end. This band should reach to some distance beyond the base of the cone ; the further the better ; and the whole must be of uniform thickness all round, so as to suffer equal compression between the cone and the working barrel. The seam or joint of the two ends of this band must be made very close, but not sewed or stitched together, for that would cause inequalities injurious to its tightness and be useless, because the two edges would be squeezed close together by compression in the barrel. This compression need not be great : that is a very detrimental error of the pump-makers, for it causes enormous friction, and actually prevents the piston from being air-tight by causing the leather to wear through at the edge of the cone, and wears out the barrel. This soon becomes wide in the part continually passed over by the piston, while the mouth retains its original diameter, and thus it becomes impossible to thrust in a piston that shall completely fill the worn part. Now, a very moderate pressure is sufficient for rendering the pump perfectly tight, and a piece of glove-leather would be sufficient if loose or detached from the solid cone ; for suppose such a loose and flexible but impervious band of leather put round the piston and put into the barrel ; and even let it be supposed that the cone does not compress it in the smallest degree to its internal surface ; pour a little water into the inside of this sort of cup or dish, and it will swell a little, and apply itself close to the barrel all round. We can readily compute the force with which it is compressed. It is half the weight of a ring of water an inch deep and an inch broad ; a trifle, and the friction caused not worth regarding ; but it is a pressure sufficient to make the passage perfectly impervious, even by the most enormous pressure of a high column of incumbent water, for let this pressure be ever so great, the pressure by which the leather adheres to the barrel always exceeds it, because the incumbent fluid has no preponderating power by which it can force its way between them ; and it must insinuate itself precisely so far that its pressure on the inside of the leather shall still exceed, and no more, the pressure by which it endeavours to insinuate itself, and thus the piston becomes perfectly tight with the smallest possible friction."

Robison draws an analogy from the construction of the valvular system in the human frame to illustrate the theory of pumps, and for the most part correctly. The inherent difficulty of such an argument consists in the enforced comparison of the objective and subjective. Matter is outside of us ; life is ours, and although the mechanism of both are mutually instructing, and in many respects the same, there is an undefinable difference, which shuts the reasoning out of court. Nature is suggestive ; science must be accurate. Life is free ; matter is not.

It seems to be impossible to supersede the use of leather in pumps. Metallic valves abound ; but they have to be faced or covered or surrounded by leather. Its service is well described by Dr. Robison, and although the information may read like news from an encyclopædia, there is a cogency, vindicated by practice, that teaches us that the old ways contain the germ, or are rather the source of all we know.

To construct a tight piston, recourse must be had to thick and strong leather. The body may be wood or metal, but the surface must be thick and strong leather. If the leather be thin, and the solid piston in any part does not press it gently to the barrel, there will be in that part an unbalanced pressure of the incumbent column of water which will burst a strong leather bag ; but if the solid piston covered with leather exactly fits the barrel, and even tightly, there is no such risk. It is the commonest form of piston, and the most simple ; it is also the most preferable to any of those more artificial and more ingenious constructions met with in the works of our best engineers.

The introduction of india-rubber has done much to supersede leather : it is more regular in its structure, and can be moulded

with the utmost exactness. It fulfils all the conditions demanded of leather, and as the various parts are always kept in stock ready to be affixed in a minute, which is of immense importance when a machine is running night and day, and every delay is very costly, it has become the favourite substitute, if that can be called a substitute which possesses almost the same characteristics. Leather kept wet does nevertheless make the most perfect clothing of all hydraulic works, because it swells until it fits, and does not swell too much, whereas india-rubber will not swell at all.

But we are anxious to describe the existing machines of this character. They are very many. They can pump out a river, and they can pump out the minutest quantity known to the chemist. Herein is the charm of knowledge; to contrast the simple, to which reference is made, with the marvellous results that have been evolved from that simplicity; to observe the progression which, commencing in a mere suction-pipe, can in a few hours transfer hundreds of tons of water whither it wills, or can by instruments as delicate as a pencil-case render service in the laboratory.

We will invert the order of succession and describe the most perfect of steam-pumps. America has done good service by the invention of machines; and every number of our journal testifies thereto. This Direct-acting Steam-pump is the work of Mr. Blake, of Boston and New York, whose name is honourably familiar among all lovers of mechanical science everywhere, and is a great name in his own land. The machine has had the highest reputation for years. Ten thousand of them are in use.

The drawings almost explain themselves, but perhaps a little detail may be of interest.

It was introduced in America in the year 1864, and has steadily advanced in public favour because of its simplicity of construction, positive action under any pressure, and perfect arrangement of all its parts, whereby it is able to run at any speed with certainty, deliver the greatest quantity of water with a lesser expenditure of steam than any other of its class. These are excellencies that cannot be estimated too highly. For mines and for water-raising such attributes make all the difference between success and failure.

The important feature peculiar to Blake's Pump is the mechanical connection between the movable seat,—which sometimes becomes the main valve,—and the main piston. It permits the pump to be run to a very high speed without danger of striking the heads. The piston cannot reach the end of the cylinders because of that mechanical connection giving a *lead* that is more certain than an eccentric.

Admit steam into the cylinders of a pressure in excess of the resistance on the pump-plunger, and it will start at any part of the stroke and work at any speed with both high and low pressure. No starting or operating hand is wanted to assist its action, and nothing can stop it unless the steam be shut off. The Steam-Valves have an ingenious arrangement that meets all the conditions described, viz., simplicity, durability, true action, and high speed. That is its distinctive mark. Two slide-valves work as perfectly when the exhaust is connected as when steam is sent away.

The operation of the steam-valves, gear, and general action of the pump will be readily understood by the following description and sectional drawing of the Steam-Cylinder and Valve-box. (Fig. 3.)

The main valve is driven by a spring-ring steam-piston, that becomes as positive in action as any steam-piston when exposed to pressure, and the auxiliary valve, plain flat slide-valve attached to a valve-rod, receives its motion from the main steam-piston; it is worked with the certainty of an eccentric. The casting forming this auxiliary valve has three ports, which

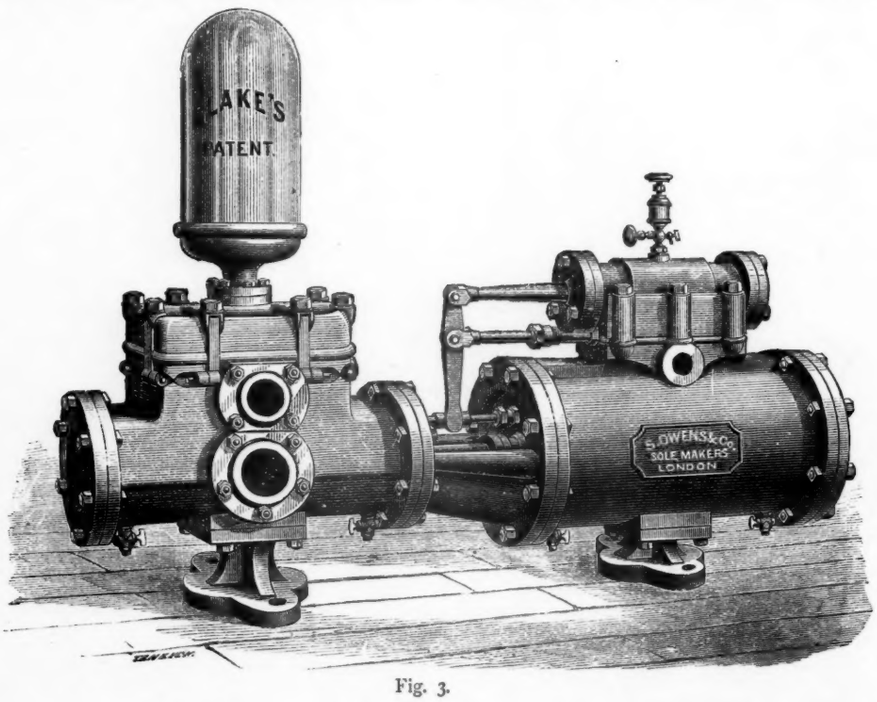


Fig. 3.

coincide with the three ports of the main engine, and form an upward extension of the engine-ports on the upper seat of which the main valve slides. If the main piston should attain a velocity exceeding that of the piston which actuates the valve it would strike the cylinder-head, but the moveable valve-seat makes that an impossibility, because having a mechanical connection to the valve-rod, it becomes the main valve, independent of the action of the main valve proper, and gives direct steam to cushion and reverse the engine.

The main and auxiliary valves being merely flat plane surfaces, and their respective positions being face to face, the wear is consequently even as well as compensating, the same as any plain steam-engine valve. The pistons are made with adjustable spring-rings, compensate for wear, and the steam-cylinder having the piston so arranged as to permit the packing-rings to revolve in the cylinder, the wear is necessarily more even than in the older plan of stationary ring-packing.

As to construction, the stuffing-boxes are made of the best gun-metal; in the event of one or more receiving injury by either breakage or wear, it may be detached from the pump and a duplicate part replaced in a few moments; and the piston-rods are made either of steel, gun-metal, or copper, and of sufficient diameter to withstand the heaviest concussions that a pump can possibly be subjected to.

For deep well pumps made to raise water from a depth of 500 feet, such as those which supply the fountains of Versailles,

great care must be exercised in their construction. All the parts have to be fitted throughout in the most substantial manner. It does not signify whether they are driven by hand or horse, or water, or steam, or even wind, they must be made most carefully, and of perfect workmanship. The small and the large are alike in this respect; there must not be any false work in their manufacture, because every part grinds, so to speak, against every other part. Paper mills, breweries, distilleries, especially require this form of hydraulic machinery, and public establishments, private mansions, and general manufacturers requiring a liberal supply of water find their service indispensable. (Fig. 4.)

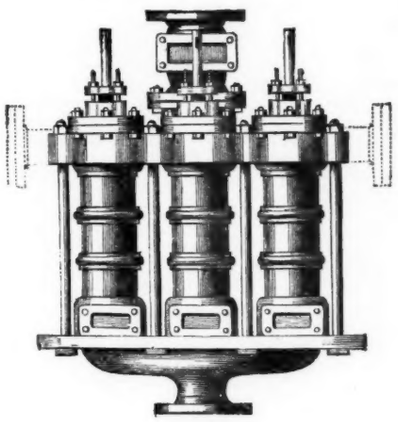


Fig. 4.

The Double-Action Pump yields an uninterrupted flow. When the piston ascends the valves open and water is drawn up the tube by the lower surface of the piston, and forced up by its upper surface. When the piston descends, water is drawn by the upper surface through the valve and forced through by the lower surface. These have not been in favour because of the number of valves and the consequent liability to disarrangement. But that in Fig. 5 has but one working barrel or cylinder, is fitted with brass or gun-metal plunger and bucket, and

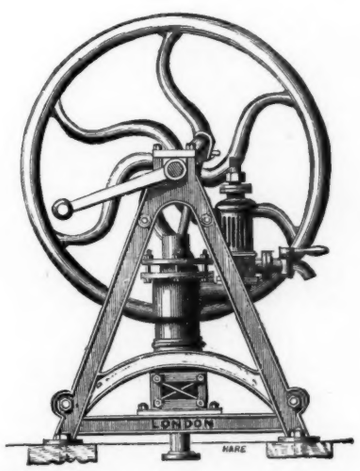


Fig. 5.

delivers water, both at the up and the down stroke: consequently, for such purposes as tank-filling, whether at railway stations or large hotels, it is in great request.

The Portable (Fig. 6.) is decidedly the best form of wrought-iron pump for raising water from a depth of 30 feet. The pipes are in short lengths, are made very strong, portable, and convenient for shipment, and when it has to be put to work, any shorter length than 30 feet can be put together. This kind has been shipped for railway works in India, South America, Russia, Denmark, and Turkey, besides being a favourite among English contractors. The most useful kind of this form is made thus: The

Fig. 6.

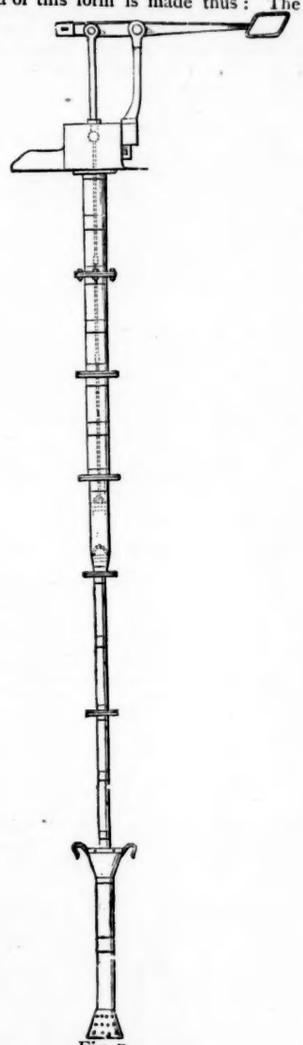


Fig. 7.

pump is 7 feet under the spout; pipe plunged at each end 6 feet; the plunged and plain-end pipe is 9 feet; the sliding suction 8 feet; and the total 30 feet.

For heavy work another is required (Fig. 7), which, while it can take as low as 20 feet, can also work to the depth of 200 feet. It is the one used by contractors. In well-sinking, in excavations, and excavations where water is wanted, or where it is too abundant, there is no form of hydraulic engine so readily adaptable as this. The illustration gives its own explanation, from which the reader can see the perfection of its working and the simplicity of its construction.

Passing from these we advert to another form much employed in Gas and Chemical Works. These are provided with doors for access to both upper and lower valves, and these valves may be made in a variety of ways as shown, suitable for different liquors, viz: A shows an ordinary leather or canvas clack valve for water or other fluids. B has a metal hinged clack, for hot liquors, &c. C shows a ground wing or spindle valve, and D a spherical or ball valve ground to seating; these two latter being specially suited for Tar and other thick fluids. E shows side view of the door to valve box, with guard to prevent the valve rising too high from seating.

The valvular arrangements of pumps finds its perfection in the modern double action one whereby valves of any description can be used. Many manufacturies that require pumps, require

their service in many ways quite different from each other, in pumping up or out fluids, altogether antagonistic ; sometimes, also, hot and cold. Valves of gun-metal have to be used, with gun-metal seatings, or of iron, with iron seatings, according to the nature of the liquor to be transferred. The gearing and arrangement of these is of the most simple kind ; it is also the least costly. They deliver up and down equal quantities and really do the work of two machines. The brewer, tanner, paper maker, drysalter, sugar refiner, and the vinegar maker use it extensively ; and all chemical works, where acids abound, find this the best of the small and inexpensive ones. It is the latest improvement.

But when pumps on this principle are required to have barrels above five in bore arrangements have to be made as shown in

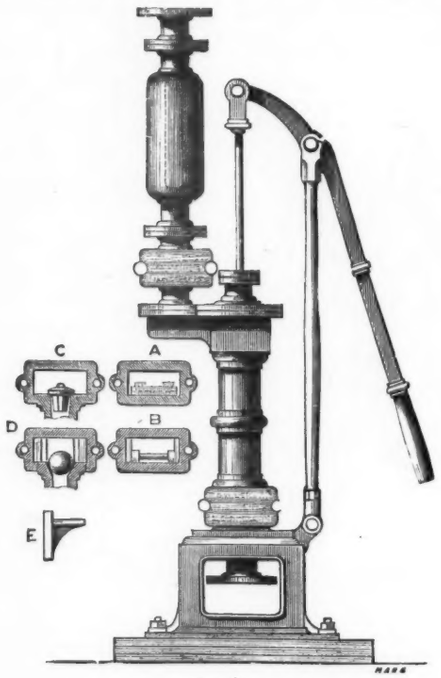


Fig. 8.

Fig. The valves must be of vulcanized india rubber, with galvanized iron or gun-metal grids and guards, except in cases, where it is desired to force water to extraordinary heights when double beat valves are used, on vulcanite seatings. In these

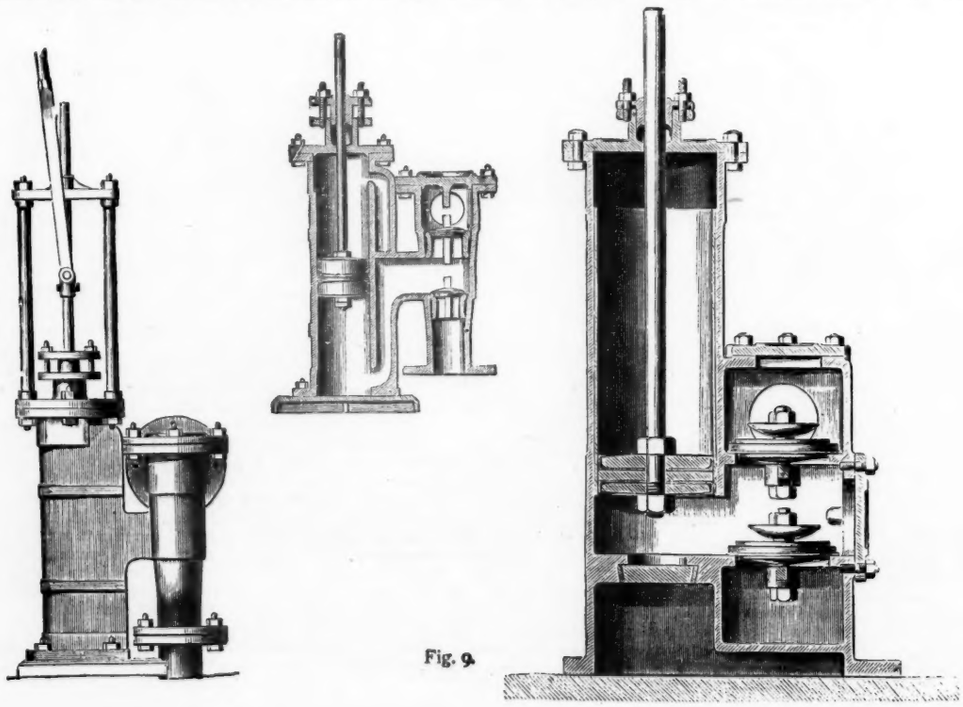


Fig. 9.

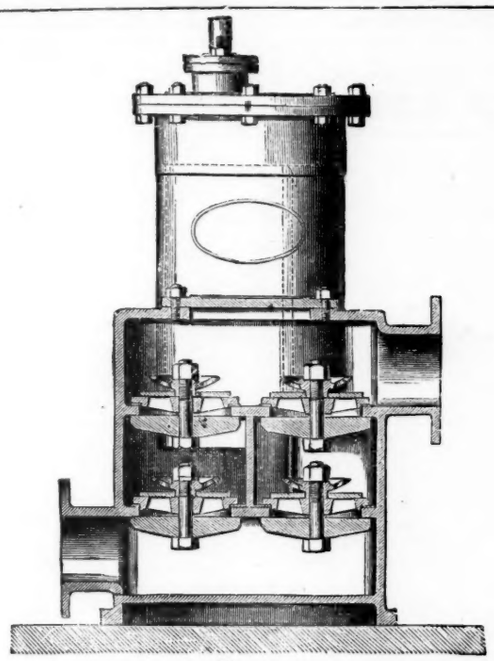
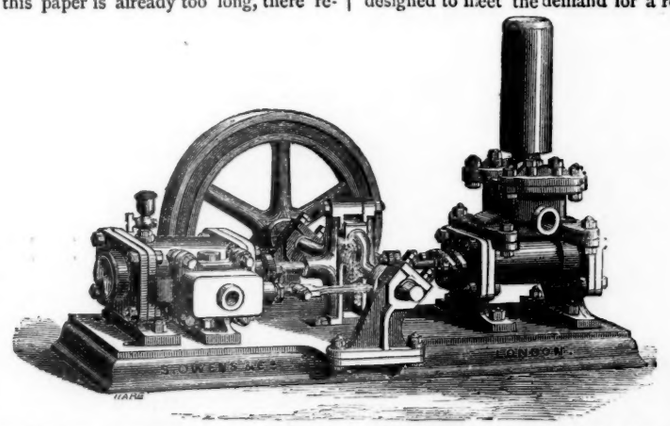


Fig. 10.

machines doors are provided to afford a ready access to the valves when they require clearing or repairing.

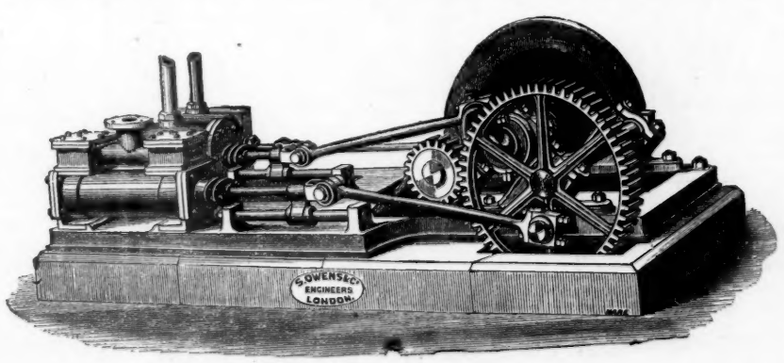
Finally, for we fear this paper is already too long, there remains a specimen of the steam pumping engine of singular utility. Fig. 01 is a double-action engine, unique and compact, designed to meet the demand for a really efficient and reliable



Donkey Engine. No pains have been spared to make it reliable as to action, efficiency, and durability.

It has not been attempted to dispense with those parts of the steam engine generally admitted to be essential to its proper working, or run into extreme simplicity.

The chief novelty is the arrangement of the valves of the



pump, which, from their peculiarity, cannot become set fast in working; and, as the valves and seatings are easily removable, they can be readily replaced by a new set, when they become defective by wear, and thus the pump may be restored to its original state of efficiency at a trifling expense.

One of the advantages of a Double Action Pump is, that a continuous feed to a boiler is maintained, and a regular and constant delivery into a tank is effected, while the duty performed is just double that of a Single Action Pump of a corresponding size; and when called into action as a fire-engine, the benefit of a continuous and regular stream delivered by a jet cannot be over-estimated.

We notice next a beautiful compact horizontal Steam Engine and Air-Pump combined, mounted on a cast-iron bed plate, with intermediate spur gearing for reducing the speed from the Steam Engine to the Air-Pump.

This arrangement has been designed specially for use in Chemical and other works where acids have to be forced from one vessel to another, to obviate the difficulty experienced by the destructive action of acids upon metal, which is the case where the acid is allowed to come in direct contact with the body of the Pump.

These Steam Air Pumps can be arranged for forcing and compressing air, and also for exhausting, according to requirements.

In making these general remarks on the variety of hydraulic machines, we are sensible of the difficulty of giving anything like a perfect view of the work science has accomplished, and is now in the course of accomplishing, but an idea can be formed of the immense field covered by this phase of ingenuity, when we say that all our illustrations are derived from one house; that we are under much obligation for the courtesy, which has aided us in the statement of what is now doing in a most interesting and useful domain of human enterprise, skill, and power.

Chemistry applied to the Arts, Manufactures, etc.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF SOCIETIES, ETC.

Water-Proofing.—M. Dujuardin's process for water-proofing textile fabrics, felt, linen, cordage, water-pipes, wood, leather, cotton, and paper, is as follows :—

Place in a mortar :

335 grammes (12 oz.) of sulphate of alumina and potash reduced to powder :

335 grammes (12 oz.) of pyrolignite or acetate of lead; and bray them till the mixture is completely deliquescent.

Add 200 grammes (7 oz.) of pulverised bicarbonate of potash, joined with 200 grammes (7 oz.) of sulphate of soda. Bray them till they are completely combined.

Pour on the whole 120 grammes (4¼ oz.) of English magnesia well calcined, and continue braying while gradually pouring 5 litres (8¾ pts.) of water.

Pour the whole into a bucket containing 11 gallons of river or rain water, which must be fresh. Shake the whole until there is complete solution, which takes place in twenty minutes. Pour the liquid thus obtained into a convenient receptacle holding about 22 gallons, in which have been dissolved 150 grammes (5¼ lbs.) of oleine soap in 11 gallons of rain or river water.

Boil for about twenty minutes. To render a texture water-proof, it is then sufficient to put in this liquid either by hand or machinery, until it is perfectly impregnated in all its parts. Care must be taken during the whole operation to stir the mixture well, that no deposit may be formed. The texture is then withdrawn, left to drip, and dried. It is afterwards washed in plenty of water, dried, and dressed as usual. In this condition the texture is water-proof, but penetrable by air, which is indispensable for health.

This process does not alter tints at all, but if the materials have very delicate tints, it is necessary to take account of the composition of these colours, and compose the bath accordingly. The bicarbonate of potash and sulphate of soda must then be sometimes replaced by the same quantity of salts of iron, copper, zinc, lead, or some other metallic salt suitable for preserving colours.

To prepare linen, leather, or wood, add 100 grammes (3½ oz.) of margarine to the bath.

When it is desired to prepare cotton or paper, it is well to add to the bath 50 grammes (1¾ oz.) of gelatine, and 100 grammes (3½ oz.) of light-coloured resin. After that you may dry in the open air or at the fire, and you have then products perfectly impermeable, which can resist every kind of washing. Paper paste may be even soaked in the vat, and thus an impermeable paper obtained, the above process replacing the sizing.—*Moniteur de la Teinture.*

Paper for Wrapping up Coloured Wool.—Dyers often get back woollen hangings which they have dyed, because, after being reeled and wrapped up in white paper, they become party-coloured at the warehouse, some parts becoming light, and the others retaining their colour. The blame is naturally laid upon the dyer, but closer observation has shown that this evil, which is especially observable with aniline colours, and above all magenta, always occurs when the yarn in question comes into direct contact with white paper. This led to the discovery of the true cause.

The materials used for making white paper—rags, straw, esparto, &c.—are subjected to strong bleaching with chlorine, and if this is not removed in the manufacture of the paper by anti-chlorine, some traces, though very slight, of chlorine will be left in white papers. But aniline colours are especially susceptible to the action of chlorine, and hence the colours fixed on wool become weaker in all places where they come into contact with the chlorine in white paper. To avoid the evil, the wool should be wrapped up, not in white, but dark paper. Blue paper is to be recommended, because the ultra-marine used for colouring it is very susceptible to the action of chlorine and acids, and therefore any trace of it left would naturally be already much neutralised.—*Bayerisches Industrie und Gewerbe-Blatt, Nov. 1876.*

Patina.—Imitation patina for bronze articles of all kinds is produced by preparing a ground colour, by mixing carbonate of peroxide of copper with bright spirit lac, and laying this green lac on the article with a brush. The green colour then remains in the indentations, and appears as patina after drying. Carbonate of copper gives a bluish patina, verdigris a bright green. Intermediate tints may be obtained by mixing these colours together.—*Blätter für Industrie und Gewerbe.*

Process for Rendering the Silvering of Mirrors White and Bright.—M. Lenoir's process for this purpose is as follows :—

The glass plate is covered with silver according to known methods. The surface is then freed from all deposit by pouring water over it. A solution of a mercurial salt is next poured on the silvered surface, for which purpose several are useful, but the following is the best.

Prussiate of quicksilver, . . .	800 parts.
Prussiate of potassa, . . .	250 parts.
Water	5000 parts.

This solution is filtered, and diluted with about ten times its volume of water. As soon as it is poured on the silvered surface, the latter becomes white and amalgamated, and the glass surface of the mirror assumes all the brilliancy of the amalgamated tin-foil mirror. The colour improves in time, as the silver coating is continually more penetrated with the quicksilver.

The solution should not remain on the glass more than two or three seconds, and should then be poured away, otherwise the quicksilver deposit might be too great and impair the brilliancy. After the solution is removed, the surface is well washed with cold water, and the glass plate set in a vertical position to drip off and dry, after which it can be lacquered and coloured as usual.—*Bayerisches Industrie und Gewerbe Blatt, Oct. 1876.*

Casting Iron Articles with Brass.—A great variety of cast articles used in buildings and art, as well as many tools, are suited for being coated with brass, partly to preserve them from rust, and partly also to improve their appearance and increase their value. Among them may be mentioned ordinary locks, door-handles, furniture-springs, cast inscriptions and shields, statuettes, cups, pans (tinned inside and coated with brass outside), knobs of bell-wires, furniture and upholstery nails, wires, rulers, &c.

Herr Hess's process for coating with brass is this : First of all the articles must be polished clean, either dry with emery powder or brick-dust, or should be pickled over-night in water containing two per cent. of sulphuric acid, and cleaned with a brush after being washed with clean water or a weak solution of soda. They are then put into the bath consisting of 2½ parts of blue vitriol, 20 parts of white vitriol, 45 parts by weight of prussiate of potassa, in 300 parts of water.

As a node or positive pole two zinc and copper plates of equal size are used, and the change of colour in the brass coating at discretion is accomplished, as is known, by plunging one or the other more deeply. A strong current is to be recommended, and many hydrogen bubbles should arise round the article. The articles must be coppered before being coated with brass.

Brass deposits well on galvanised iron, and adheres firmly. The same holds good of the combination of iron and copper articles.—*Pataky's Metallarbeiter, No 39.*

Postal Progress.—Some idea of the advance in education and interchange of thought in Europe, during the last fifteen years, may be gathered from the following statistics published by the *Economiste Francais:*—

Number of Letters Posted in Millions.

	1860	1865	1870	1875.
England,	564	720	990	1,100
Germany,	193	228	582	643
France,	263	313	305	366
Austro-Hungary,	105	120	269	285
Switzerland,	29	37	56	73
Belgium,	24	34	64	68

There are no exact data for the other countries of Europe during the last fifteen years, but from an official document published by the Minister of Finance in Austria, it appears that about 2,922 million letters were posted in Europe in 1875. The *Economiste Francais* calculates that in the same year the number of letters posted in non-European countries amounted to 980 millions; so altogether 3,900 million letters were posted in that year—*i.e.*, more than 10½ millions a-day.

The following table shows the number of letters and papers posted in comparison with the population during the year 1875:—

	Number of Letters per Inhabitant.	Newspapers and Packets per Inhabitant.
Great Britain,	34·5	5·2
Switzerland,	27·3	17·2
Germany,	15·3	11·7
Holland,	14·6	7
Luxemburg,	11·2	8·3
Belgium,	13	12·5
Denmark,	11·7	10·7
Austria,	10·6	2·9
France,	10·2	4.8
Norway,	5·6	unknown.
Sweden,	5·5	5·6
Spain,	4·8	unknown.
Italy,	4·5	2·4
Hungary,	4·4	1·8
Greece,	2·1	unknown.
Russia,	·8	·5
Roumelia,	·5	unknown.
Turkey,	·2	·1

Servia and Portugal are without postal statistics.
—*L' Economista, Jan. 7, 1877.*

The Preservation of Linen Stuffs and Yarns.—Sails, ropes, nets, &c., keep much longer when they have been treated with tannin. Hence M. Lebrun recommends the following process for preserving linen goods and yarn. A kilogramme (2¼ lbs.) of good oak tan is boiled for half an hour in 20 litres (4½ gall's.) of pure running water. After filtering and pressing the residue, you get about 15 litres (3¾ galls.) of tanning liquor. With this the stuffs or yarns are brewed in copper, earthen, or wooden vessels, but not in iron. The fluid must completely cover the stuffs or yarns, which should be left in it for 48 hours, and stirred round in it from time to time. They are then to be taken out, wrung, washed, wrung again, and, after being dried, they show a slight leather-like colour, and withstand all the effects of damp and the action of the weather much better than those not so treated.

Unbleached goods may be treated in this way as well as bleached, but they must be first steeped. Linen goods that are already partly decayed may be thus protected from further injury. Linen goods subjected to this process for 72 hours have been found unaffected by lying spread out for ten years in a damp murky cellar, while untanned goods were almost completely destroyed.

Hitherto carbolic acid, pyroligneous acid, chloride of zinc, blue vitriol, and other metal salts have hitherto been thought the only preservatives of wood, but it has been found that wooden frames treated with tannin have been kept uninjured for ten years, while others not so treated have decayed.—*Deutsche Polytechnische Zeitung.*

Benzine Vapour in Lighting Gas.—According to a paper by M. Berthelot in the last number of the *Annales de Chimie et de Pharmacie*, the vapour of benzine plays a very important part in increasing the brilliancy of Paris gas. By bringing the gas into contact with nitric acid nitro-benzine is formed, which is afterwards converted into aniline, which may be detected by certain tests in almost infinitesimal quantities. M. Berthelot's researches fully confirm Dr. Franklin's discovery, that the illuminating power of a flame is dependent not so much to the numerical proportion of the carbon to the hydrogen contained in the burning substance, but rather to the degree of condensation of these elements in a given volume.—*Annales de Chimie et de Pharmacie, May 1877.*

A New Process for making Nitro-glycerine.—In the ordinary process for making this formidable explosive by gradually mixing fuming nitric acid and glycerine, it is almost impossible to keep the mixture from heating, especially when working on a large scale, whereby the major position of the nitro-glycerine becomes decomposed as fast as it is formed, escaping into the air in the form of red fumes. Even if the vessel in which the operation is performed, be plunged into a refrigerating mixture, certain parts of the liquid become hot and rapidly spread decomposition throughout the whole charge.

MM. Boutmy and Faucher have devised a process by which the danger of decomposition is reduced to a minimum. Instead of acting directly on glycerine with nitric acid they use a glycerine compound. They first prepare sulpho-glyceric acid by treating glycerine with three times its weight of strong sulphuric acid. The resulting sulpho-glyceric acid is then mixed with due proportions of nitrosulphuric acid containing equal parts of the two constituent acids. The reaction is generally complete in about twenty-four hours, the temperature of the liquid never rising above 55 degrees or 60 degrees F. The formation of the nitro-glycerine goes on very slowly, and the new compound being lighter than the liquid in which it is formed rises to the top, whence it may be syphoned off, when the operation is complete. MM. Boutmy and Faucher have not yet succeeded in obtaining the theoretical quantity of nitro-glycerine from a given amount of material, owing to the action which takes place being somewhat complicated. They are, however, continuing their researches into the perturbing influences, which cause the same materials to yield different results under apparently similar conditions.—*Annales de Chimie et de Pharmacie, May 1877.*

Cleansing Greasy Rags.—A new method of cleansing greasy woollen or cotton rags and waste has just been patented in Germany. The rags are thrown into a closed revolving drum with a quantity of perfectly dry and finely-powdered plaster of Paris; when the plaster has absorbed all the grease the whole is transferred to another revolving drum, pierced with holes by which means the greater portion of the greasy plaster is got rid of. The operation is finished by beating the rags on a kind of wooden sieve.—*Moniteur de la Teinture, April 1877.*

M. Jabloschkoff's Electric Candle.—We announced some time since that a Russian electrician had effected an important improvement in the electric light by doing away with the complicated apparatus for keeping the carbon points at the proper distance from each other. This was effected by means of what M. Jabloschkoff called an electric candle, which consisted of a cylinder of an argillaceous composition, in which the carbons were imbedded side by side. He has now so far solved the problem of applying light to artificial illumination as to do away with carbon electrodes altogther, and to be able to divide the light into any number of distinct "candles." Each "candle consists of a small plate of porcelain over which the spark is passed by means of a "priming" of conducting material. The porcelain immediately becomes white hot, giving out a brilliant light which for steadiness and softness is unequalled by any known artificial illuminating agent. M. Jabloschkoff works with a double current produced by any ordinary dynamo-electric machine. He obtains these wonderful results by introducing into the central circuit of the machine the interior wire of a series of induction coils. By placing a great number of bobbins in circuit, and dividing these into sections, as many as fifty lights may be obtained from one machine of medium power. The invention has already been exhibited in the great hall at the Magasins du Louvre. It has also been exhibited at one of the docks in the Isle of Dogs. We shall return to this interesting subject.—*Comptes Rendus, No. 16,* 1877.

A Valuable Alloy.—A French Metallurgist has invented a new alloy which gives a perfectly white metal which is inoxidisable in dry or damp air. It resists the action of sulphuretted hydrogen and the vegetable acids, and is only slightly acted on by the mineral acids. It is much cheaper than German silver, and consists of 66 parts of iron, 23 of nickel, 5 of copper, and 4 of tungsten. Sideraphthite is the silly name bestowed on this new alloy.—*Les Mondes.*

Standard Weights and Measures in Canada.—The Inland Revenue Department of Canada have placed the city of Ottawa, as regards standard weights and measures, far beyond that of many of the largest towns in the United Kingdom, whose local officers are only too often provided with instruments of the rudest and cheapest form, and whose technical knowledge is frequently of the most meagre description. The Weights and Measures Department at Ottawa is now furnished with complete sets of standard weights, furnished by such well-known firms as Troughton & Sims, Oertling, J. J. Griffin & Sons, Whitworth & Co. and several others. In other branches such as the analysis of gas, water, and food, Ottawa has placed herself in a similar high position. Such liberality speaks loudly for the advance of the material prosperity of the dominion. It is only fair to say that the initiatory step of the good work was taken by Col. Brunel, the Chief Commissioner of the Inland Revenue.

A Spanish Association for the Advancement of Science.—We are glad to hear that a number of Spanish *savants* propose the formation of a scientific body similar to our British Association. The Madrid Societies of Natural History, Anthropology and Geography have taken up the matter warmly, and have formed a joint committee to carry out the scheme.

War versus Science.—One out of many of the disastrous effects of the disastrous war in the East is, that owing to the St. Petersburg Government having refused the usual annual grant to the Congress of Russian Naturalists, that body will not meet this year.

Sugar Loaves.—The classical sugar loaf is fast disappearing in Germany and France, manufacturers and retailers finding square flat cakes much more convenient for cutting up than the old fashioned "loaf." The expressions, "sugar loaf" and "bullet headed" will, we fear, give rise to a good deal of speculation amongst the etymologists of the next century.

Practical Literature.

BUSINESS MANAGEMENT.[1]

PERHAPS it would be unwise to set out a code of duty for a young fellow taking his start; he had better go as a novice, and feel his feet and find his place by the accident of circumstance, although the way is mean and often thorny. The young man has his own idea about all that; and if it is possible for him to escape trouble and know what is required of him in the calling selected, he will be glad to make the best use of that opportunity without incurring the risks of knowledge that comes by experience.

We are glad of such aids. Knowledge that comes by experience is no doubt of enormous value; but it is a very expensive article, and in nine cases out of ten is not worth the money, because it entails associations or consequences that are more or less disastrous. If a young man is sufficiently docile to listen to the voice of wisdom, he will save himself a fountain of useless tears, and acquire a strong position.

Builder's clerks have a very important position in our social arrangements. Their employers and the outside public depend upon their fidelity for the profitable and good execution of contracts. Estimates, invoices, claims, projects, rates of profit, nature of risk to be accepted, provision for wages, and general correspondence; these are committed to him. The employer must be busy in negotiations, and in seeing that works are being carried on; the clerk ought to be the man of brain, of order, of exact knowledge. The work of Mr. Dales is admirable. It teaches the juvenile what is expected of him; it teaches the practitioner, no longer a novice, what are his duties and his responsibilities: it teaches all employers what their clerks ought to do. And no employer can rise from its perusal without feeling that, among all his friends, his confidential clerk is the best.

[1] *The Builder's Clerk. A Guide to the Management of a Builder's Business.* By Thomas Dales London: E. & F. N. Spon. 1877.

HOUSE DRAINAGE.[1]

MR. FIELD has herein given the world a little code upon a most delicate and controverted subject. We are not disposed to magnify unduly the importance of House Drainage, because where life is carried on with something like freedom disease does not attack. The repellant force of a well-ordered and well-fed nature is sufficient to put aside the arrows of disease which may spring from a roughly constructed system of drainage. But all are not strong; and notably the women and children of the house have not the nature or the culture to make them invulnerable. If the drains are badly-made or ill-protected, there is no remedy; they become the victims of blood poison. Hence there must be local laws of the most absolute character appertaining to, and inclusive of the peculiarities of a given district. This is herein done for the parish of Uppingham. In it is described the objects of drainage; these are the immediate removal of foul matter and the prevention of back current of foul air into the house. To perfect a system other means than cesspools and drains are required; there must be a disconnection or a break with free communication to open air; and with that disconnection there must be good ventilation, which ventilation is not understood by many: for its effectiveness he contends for *two* openings of ample size. He advocates disconnection in every way—sinks, traps, closets, and endeavours to show how a stream of pure air can be produced.

Croydon has had a marvellous history in respect of water supply and drainage. The first to suffer and the first to reform, that little town has a record that should save mankind from a catalogue of ills in other towns. It has had, and has, its quacks, but the common sense which rules there has at Uppingham succeeded, and Mr. Field is the lawgiver. He prescribes how drains should be laid, and how they should be protected when running under a house. Private as well as public personages will find the difficult subject treated in a practical manner by one who has watched and observed with great intelligence.

WOOD PAVEMENT.[2]

MUNICIPALITIES have as much trouble about paving as they have about anything. In the first place, the choice of a system must be governed by local conditions. Some towns are hilly, others are flat; some are places of miscellaneous resort, and partly pleasure towns, while others are prosaic and manufacturing or agricultural. Manifestly no hard-and-fast law can be imposed as to the regulation of their highway arrangements. Large towns have, however, come to a conclusion in some respects. Few desire to perpetuate the Macadam method for principal streets; it is too rough in its beginning, it is too transient in its service, and is always causing some trouble. Asphaltes work well in some places, and in others it is exactly the opposite. The general tendency is toward the adoption of wood pavement; the difficulty of finding which is the best system remains still. The pamphlet noticed here sets out the advantages which are especial to the proprietors of the patent of the London Wood Pavement Company.

"A 'true system' of wood pavement would provide for the conveyance to the drains and sewers of the surface water, so far as possible, but would allow the earth to perform its natural functions by carrying off or retaining such other water as might, by any chance, percolate through the seams of the blocks to the bed underneath, and this is done by a system just adopted in St. Pancras. The bed, upon which the blocks rest, is made as firm as possible; but this firmness is by a simple contrivance obtained without sacrificing its porosity. This is its cardinal feature, but it is also distinguished from some other systems of wood pavement, by the fact that the blocks are all laid vertically. Care is taken to prevent the percolation or filtration of surface water as far as is possible—and quite as effectually as by any other system—but such water, as may in spite of all precautions find its way to the bed, is then absorbed by the material underneath.

"The first step is to excavate and level the ordinary roadway

[1] *Bye-Laws and Regulations with Reference to House Drainage, &c., &c.* By Rogers Field, Member of the Institute of Civil Engineers. London: Spon. 1877.

[2] *The True System of Wood Pavement.* London: E. & F. N. Spon.

to the required depth and dip. When that roadway or bottom has been so well made, it is covered over with a bed of clean sharp sand, six inches deep. Upon this sand is laid a series of rows of wooden blocks, or cubes, on end, across the street. Between each row of these wooden blocks, or cubes, are driven wedges one inch in thickness, and when a sufficient number of these blocks and wedges are laid to hold the sand firmly, the latter are driven below the surface of the roadway to the depth of three or four inches below the bottom of the level of the blocks into the bed of sand."

ELECTRICITY AND THE ELECTRIC TELEGRAPH.[1]

WE very much doubt whether any age of civilisation has been destitute of the consciousness that a secret force of universal application for purposes of communication and for general utility awaited manifestation. Traces are to be found in every age and clime, where natural forces had obtained anything like appreciation, of this instructive conviction. It had no basis; it could not recite or tabulate facts; it remained a vague belief; but as positive as if sustained by evidence. Electricity has emerged from that hidden world, and has more than realized the dreams of dreamers, the hints of sages, and the hope of philosophers. It is yet in its childhood. We shall know more yet, much as we have learned; we shall receive impetus in science, medicine, and in discovery, far, very far beyond what has yet been vouchsafed. This is true not only of electricity. There are other worlds awaiting conquest, and, beyond these, others will assuredly be offered to the wondering student of nature and nature's resources. The common atmosphere has treasures ready to be yielded to the ardent labourer in the field of science, and water has not half run out its prolific catalogue of blessings designed for the comfort, help, and nourishment of men.

The basis of progress changes with every advance, and in a world such as electricity has opened wherein new discoveries crowd with a rapidity scarcely conceivable, it is imperatively necessary to pull up from time to time and survey the region: try to realize the position reached, and explore for the purpose of learning in what direction future investigation shall be best made. The chemist has long found this process unavoidable. He has learned that the growth of knowledge necessitates a great toil of wilful forgetting: he must get free of masses of what, in his early days, seemed to be incontrovertible. We do not say that Electric Science has reached such a stage, but there is a stern necessity for its devotees to keep abreast of the age, for if they do not they will soon find their laggard pace most perilous. They had better never have known than cease to learn.

Mr. Prescott's book sets forth the position of his favourite subject at the present time. So far, it is a text-book "acceptable, not merely to the professional telegraphist, but to all who are in any way interested in the progress of Electrical Science, and in its various applications to the useful arts." From frictional electricity to telegraphy, and thence to submarine cables, and thence to telephony, there are hundreds of stages each marked by the life and study of eminent men. The history of this process of development is of the utmost value to the practitioner; it is of incalculable importance to the noviciate. He will learn to avoid wasting time and investigation about things already known or already rejected, and thereby acquire humility; and he will be able to gather up many a fragment dropped by his predecessors, and unnoticed by his contemporaries, by which he may not only do honour to those who have gone before, but introduce himself to honourable association and distinction. So has it been with the labours of Watt. His models have not yet yielded all their story in connection with the steam-engine. Indeed, in every department of mechanical, manufacturing, or philosophical science, there are riches scattered among the chronicles of the past that deserve the exploration of every succeeding generation. Books of the kind now before us are of great utility, by collecting and arranging data that yields as much knowledge in a fortnight's reading as could be obtained by two years of miscellaneous investigation. The reader discerns the essential principles as the dominant facts come before him; and it is not possible to overestimate the infinite benefits which the human mind is capable of deriving from a perfect knowledge of principles. Indeed, it is exactly in proportion to the perfection of such knowledge that power is created or acquired.

Electricity occupies a place in intellectual society, best defined by an old fashioned term—it is one of the liberal arts. Hence is it seen that many most important acquisitions of knowledge therein have come to the world from the investigations of merely searchers after truth, who sought no commercial or social advantage, but desired to explore the riches of the universe by a deep and patient pursuit of knowledge for its own sake. Wheatstone's endeavour to improve musical instruments, which was his calling, led him very near indeed to telephony, and certainly led him to be one of the greatest of modern electricians. Franklin, the politician and polemical printer, made his recreation subservient to a deeper acquaintance with the hidden springs of universal laws in nature and in matter, and if we look over the biography of electricians, we shall find great numbers who indirectly have been drawn into the circle of that company by a mere love of investigation of the purest and loftiest character.

Almost all treatises of the kind under consideration are historical and chronological, that is to say, they begin with Shakespeare's Ariel and end at the Atlantic cable. Anybody with sufficient industry can make books of that kind, but Mr. Prescott avoids such methods. There is nothing about the history, but all about the existing knowledge associated with the various forms wherein electricity has been utilised; and this knowledge is all put before the reader in intelligible scientific terms. Of course, the basis consists of the enunciation of facts and experiments collected or made before applied electricity existed,—when the whole of what was known produced more interest by its attractive surprises; when no indication existed of a kind to lead men of leisure and science to guess which way it could be made serviceable to the world. And it is exceedingly interesting to notice in this volume the blending of new and applicable facts with the old facts belonging to frictional electricity, and the primary divisions into positive and negative. Faraday is referred to most appropriately. He always built upon the crude notions of elementary science, and surrounded them with defences, or cast new light upon them; thereby carrying on the great unfolding of a mystery, hidden only from our defective capacity or industry as to detail, and as to the service it could render.

The most prominent of the uses of electricity are connected with telegraphy and the treatment of metals. Mr. Prescott supplies us with five hundred illustrations of the machinery which has been introduced, and for the most part still remaining in use. Frictional electricity suggested the idea of telegraph construction to Winkler of Leipsic in 1746, to Walson of London in 1847, and also to Le Mounier at Paris. These were simultaneous, but it was not until 1774 that [illegible] of Geneva constructed a telegraph consisting of twenty-four insulated wires —one for each letter of the alphabet. Then followed signaling by sparks. But when in 1800 the discovery of the Voltaic pile was made a new field opened for the more practical system. Twenty years of divers experiments ensued, when Oersted of Copenhagen made the brilliant discovery of electro-magnetism, which was immediately followed by attempts to utilize it for telegraphic purposes. Another twelve years (1832), and Baron Schilling announced the needle instruments, which, upon his death, were carried out by Gaus & Weber in 1833, whose apparatus consisted of a single magnetic needle enclosed in a coil of wire, the currents being produced by a magneto-electric inductor.

Then followed Morse, Wheatstone, and many others, of whom much has been said in this journal at various times. Mr. Prescott describes in detail the whole arrangements in all their intricacy and progression, so that if one desired to do all the work over again which has been done by electricians, there is a perfect delineatory guide, and this makes his book of immense value in all educational labour, in professional labour, and for the information of the connoisseur or the abstract man of science. There is an excusable tendency to award to America exaggerated merit, both in inventions and improvements; but the subject is great enough, and the enthusiasm of inventors so intense and generous, that no one cares to excite a controversy on the subject. The world is indebted to every civilised land for its electricians, and the discoveries which have followed in rapid succession have been made frequently in two or three places at one time that had no communication with each other. The idea of plagiarism is therefore inadmissable.

Descriptions of the Type Printing, Dial Needle, Reporting and Private Line, Automatic, Autographic, or Copying Telegraphs are supplied; and in every case where there have been two or more kinds each is described with the utmost fairness. No inventor can complain of being overlooked or undervalued—at least in a general way. Further, we have chapters on Pneumatic and Harmonic (Telephone) arrangements: the Measurement and Testing of Land Lines and Submarine Cables, to which are appended a Dictionary of Technical Terms, Copious

[1] *Electricity and the Electric Telegraph.* By George B. Prescott. With Illustrations. 18s. New York: Appleton; London: Spon.

Tables, and a full Index. There has not appeared any work so comprehensive in its conception and so complete in its arrangement, and it therefore is highly creditable to the author, while its production is worthy of the establishment from which it emanates.

HYDRAULIC TABLES.[1]

AN engineer, officially connected with the Irrigation Branch of the Public Works Department, Panjab, India, has issued a series of Hydraulic Tables for finding the Mean Velocity and Discharge in Open Channels, specially adapted to the most recent formulæ. Generally this has been presented in a single table, but in the present work two factors, the product of which will give the required values are in two tables ; thus making it possible by moderate calculations to tabulate values for a far more extended range of channels, and thereby include almost all the cases in which tables are commonly applied. A further plea for this publication arises from the non-existence of any generally accepted formula for determining such velocities. Every engineer makes his choice, and as all existing tables are based upon the previous labour of others whose calculations are more or less discarded as obsolete, they are of no scientific value. Mr. Higham illustrates his argument by quoting the several formulas of Dubuit, Bazin, Gerard, De Prony, Young, St. Venant, and Ellet. These are examined, and the objections recited ; such arguments leading to the conclusion that the author, Mr. Thomas Higham, has done a good action in exposing the result of his knowledge drawn from experience. The tables are adapted to the formula $v = c\sqrt{rs}$, whether c be regarded as a constant, as in the old text-books, or as a coefficient varying in accordance with a definite law. The first two aim to facilitate the calculations of the velocities and discharges of trapezoidal channels, varying in bed with from 1 to 300 feet, and having side slopes of ½ to 1. The remaining seven work out the several varieties. These are followed by examples in the use of the Tables, and the Tables themselves, accompanied by ruled paper for the student to practise himself therein.

The position of the author and his knowledge derived from practice, give to the book an authority which is not likely to be without influence on the generations that will follow.

METROPOLITAN BRIDGES.[2]

THE municipalities of Great Britain cannot avoid observing the course of events that affect the traffic over bridges. Water communication is a large source of good, in comfort and revenue, to a city or town ; and it is also a department environed by adventures and beset with projects, because any change would have the effect of distributing large sums of money, and one third of the projects only are worth discussion : the adventurer is eager for his share of the coin, and the schemer fights for dear life in the hope of acquiring popular affection for his—above all,—the best project. Nevertheless, as cities cannot help growing when they are well placed, and when the inhabitants have public spirit, which is the indispensable qualification for a municipality, the very exigencies of their growth enforce improvements. Wharves, quays, granaries, markets, bridges and public ways inland, are an unending current of requirements, that cannot be evaded without bringing upon the city or town political and commercial atrophy. England has dozens of instances of neglected opportunities, bringing degradation and contempt ; and if these have, as they have, in many cases risen from that self-abasement by a revival of energy, it has taken a generation to recover what need not have been lost for one day, and which on the contrary would in that period have made the town creditable and prosperous.

Therefore it is that London is compelled to work at all such difficulties the moment they arise ; she cannot permit neglect and will not bear unreasonable delay. Never in haste, but never flagging, she sits representing municipal life in all its anxieties, hopes, efforts, responsibilities, and bent on success.

A general impression has been felt for more than fifty years that London Bridge could not remain the first barrier of the high river traffic. Brunel, as we spoke in January, wrought hard on that wonderful master-piece of engineering in 1820-25, the Thames Tunnel, because of this impression and conviction, and now, that it has been converted into a railway, after fifty years of ill-success, it is realising the original design of relieving the heavy traffic.

But Bermondsey and Rotherhithe have grown ; and East London is growing day by day. Few properties of bricks and mortar are so worthy the capitalist's regard as the discarded mansions in the fine old thoroughfares of the East. The consequence is that, while all the fun, frolic, and folly of London has gone westward in the forlorn hope of finding rest, every month proclaims that warehouses, merchants, bankers, and traders have a more profitable location eastward than westward of St. Paul's.

London Bridge cannot be widened to advantage. What is the use of extending its lateral area while leaving the two ends and all the collateral approaches as they are? It would be not only folly, it would be waste. Had the London Bridge Terminus been brought over to Monument Yard, as proposed originally, and space cleared then at very low rates for the approaches as it might have been, our difficulty would not be here to face us. There is, therefore, no remedy for this overgorging of highways but to provide another one at a lower rate and upon better terms.

Messrs. Webb & Bolland, Members of the Institution of Civil Engineers, have enunciated their plans in an appeal to the public press, and although we are somewhat chargeable with the consequences of delay in not acknowledging their communication before, it is fair to urge that the whole scheme is undergoing supervision, and the many inventors' claims and arguments examination. The pamphlet before us is very general. It discusses the port of London and the old bridges. It speaks of the present bridge, and then enters on its own business, the "question of a new bridge and the proposals for its widening." From these it alludes to the proposals for crossing the river without interfering with London Bridge, such as the Tunnel, then the Hydraulic Lift Bridge, discarded ; the High Level Bridge, also rejected : the Subway ; the Steam ferry ; and lastly, the bridge patented by Mr. Barnett, which is a copy of a very old one, and ought not to have been re-patented now-a-days by an Englishman. He also offers a kind of opening bridge, such as we see at Katherine Docks ; a kind of bridge that cannot claim the honour of having an inventor, and which would certainly be exposed to disastrous issues when made. Lastly, he advocates a low-level continuous bridge as the best of all, coolly recognising the inevitable disturbance of the London Bridge and Custom-house trade as of no present account. That trade, with all its wharfages and quays, its landing places and its city associations, must pass away, because, forsooth, a tithe of the trade on the road desires to get into Surrey half an hour sooner ; and no one be aided by the change.

Recognising the connection of North and South in all tradings, and the perfect independence of the East as regards the West, it is refreshing to be conscious that the Corporation of London, like those of the provinces, is worthy of our confidence, and that there is no more chance of such a scheme being realised, as of our mortal eyes beholding the passage to the Elysian fields.

THE CAUSE OF ACTIVITY IN EARTHQUAKES AND VOLCANOES.[1]

"HEAT has no explosive power. Blast furnaces never explode ; but if water obtains entrance, a steam explosion instantly occurs. The sun, supposed to be the largest and hottest body, never explodes. Therefore *steam is*, and heat produced by the crushing of rocks *is not* the cause of activity in earthquakes and volcanoes."

These are the conclusions arrived at by Mr. Peacock, and the facts he adduces strengthen his case. We all want to know more than has yet been told, and therefore are compelled to construct theories. These theories contain the unknown, and their discussion is the best method we have for learning more than has yet been ascertained on this important branch of physical science. The writer says : "It is my firm belief that the facts which I have laboriously and diligently assembled together, *cannot* be explained away, but will have to be accepted ultimately." There is no doubt that "Geology is progressing in particular groves," and that we have much to learn concerning the interior convulsions of this planet, and their relation to the exterior condition of the globe.

1 *Hydraulic Tables for Finding the Mean Velocity and Discharge in Open Channels, specially adapted to the most Recent Formula.* Calculated and Compiled by Thomas Higham, Government Engineer, Panjab. London : Spon, 48 Charing Cross.

2 *London Bridge. Shall London Bridge be widened or a new Bridge built, near the Tower.* By E. B. Webb and J. Bolland. London : Spon, Charing Cross.

1 *What is, and What is not, the Cause of Activity in Earthquakes and Volcanoes.* By R. A. Peacock. London and New York : Spon.